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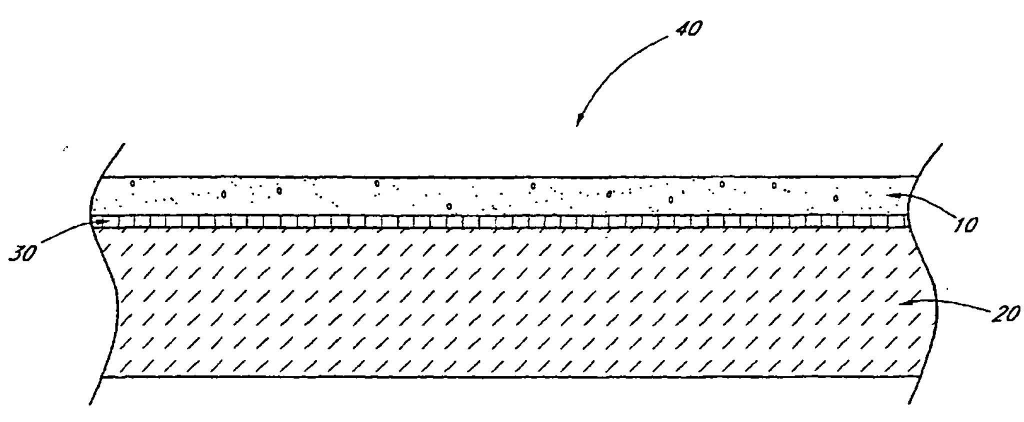
(54) Title: FIBER-CEMENT/GYPSUM LAMINATE COMPOSITE BUILDING MATERIAL



(57) **Abstract:** A building material (40) is provided comprising fiber-cement (10) laminated to gypsum (20) to form a single piece laminate composite. This single piece laminate composite exhibits improved fire resistance and surface abuse and impact resistance, but achieves these properties without the excessive weight and thickness of two piece systems. Additionally, because of the reduced thickness, the preferred laminate building material is easier to cut and is quicker and easier to install than two piece systems. Furthermore, forming the fiber-cement and gypsum into a single piece laminate eliminates the need to install two separate pieces of building material, thereby simplifying installation. In one embodiment, a 5/8" thick laminate composite is provided comprising a 1/2" thick gypsum panel laminated to a 1/8" thick fiber-cement sheet, the laminate composite having a fire resistance rating of 1 hour when measured in accordance with ASTM E119.

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FIBER-CEMENT/GYPSUM LAMINATE COMPOSITE BUILDING MATERIAL

Background of the Invention

Field of the Invention

This invention relates to abuse resistant, impact resistant and fire resistant building materials, and more particularly, to a single piece laminate composite building material of fiber-cement and gypsum.

Description of the Related Art

The interior wallboard market has been dominated by the use of gypsum wallboard products for many years. The gypsum wallboard typically comprises thin paper layers wrapped around a gypsum core. For example, one paper layer covers the face and long edges of the board, and the second paper layer usually covers the back surface of the board. The core is predominantly gypsum, and can be modified with additives such as glass fiber, vermiculite and mica to improve fire resistance.

In addition to fire resistance, abuse resistance is another desired quality in wallboards. Gypsum has poor abuse resistance compared to other wallboard materials such as wood or masonry. The paper surface of gypsum wallboard is easily damaged by impact such as scuffing, indentation, cracking or penetration with hard or soft body objects such as furniture, trolleys, toys, sports equipment and other industrial or residential furnishings. Such wall abuse is typical in high traffic rooms such as corridors, family living areas, gymnasiums or change rooms.

Gypsum wallboard manufacturers have made modifications to their gypsum wallboards to improve their abuse resistance. One method was to bond a plastic film to the back of the wall panel to resist penetration of the impact bodies into the framed wall cavity. Another method was to make a fiber-gypsum wall panel with fiber-gypsum outer layers formed onto a gypsum-based core. These products typically have improved surface abuse resistance to the paper surface of normal gypsum wallboard. Similar gypsum-based or cement gypsum-based compositions are typically described in U.S. Patent No. 5,817,262 and U.S. Patent No. 5,718,759.

One material having significant abuse resistance is fiber-cement. Fiber cement has an advantage over gypsum panel with respect to surface abuse resistance such as wear and abrasion. One disadvantage of fiber cement by itself as a wall panel is that it does not have a fire resistance rating comparable to gypsum wall panels of equal thickness. Another disadvantage of fiber cement by itself is that it is significantly heavier than gypsum wall panels of equivalent thickness. For example, a 1 hour fire resistance-rated wall system with fiber cement requires mineral insulation in the wall cavity or a sub-layer of fire rated gypsum wall panel to achieve a 1 hour fire resistance rating when tested in accordance with ASTM E-119.

A 2-layer system of ¼" fiber cement over 5/8" type X fire rated gypsum wallboard has been used to achieve both fire resistance and abuse resistance. Such a system is described in Gypsum Association - Fire Resistance Design Manual - GA FILE NO. WP 1295 - Gypsum wallboard, steel studs, fiber-cement board proprietary system. This two piece system is disadvantageous because it is significantly heavier than single-layer gypsum wallboards. Additionally, the 2-layer wallboards require nearly double the amount of labor for installation because two separate wall panels

must be installed instead of a single panel. Also, the extra thickness of the 2-layer systems (5/8" + ¼" = 7/8") is not compatible with most door jamb widths.

Summary of the Invention

Accordingly, what is needed is a single piece building material that has good abuse resistance, impact resistance and fire resistance. This building material should also be light, easy to manufacture and compatible with standard building material sizes. With respect to fire resistance, it would be especially advantageous for such a material to have a fire resistance rating of at least one hour as measured by ASTM E119.

Briefly stated, the needs addressed above are satisfied in one embodiment by a building material comprising fiber-cement laminated to gypsum to form a single piece laminate composite. This single piece laminate composite exhibits improved fire resistance and surface abuse resistance, but achieves these properties without the excessive weight and thickness of two piece systems. Additionally, because of the reduced thickness, the preferred laminate building material is easier to cut and is quicker and easier to install than two piece systems. Furthermore, forming the fiber-cement and gypsum into a single piece laminate eliminates the need to install two separate pieces of building material, thereby simplifying installation.

One object of the invention is to provide a building board product suitable for applications requiring surface abuse resistance, improved impact resistance and a 1-hour fire resistance rating (as measured, for example, by ASTM E-119) without cavity insulation at a panel thickness of 5/8", installed on each side of a wall frame. The surface abuse resistance is measured by abrasion tests such as ASTM D4977-98b (Standard Test Method for Granule Adhesion to Mineral Surfaced Roofing) and also indentation tests such as ASTM D5420 (Impact Resistance of Flat, Rigid Plastic Specimen by Means of a Striker by a Falling Weight (Gardner Impact)). The panel impact resistance is typically measured by, for example, ASTM E695 (Measuring Relative Resistance of Wall, Floor and Roof Construction to Impact Loading), and ISO 7892 (Vertical Building Elements- Impact Resistance Tests - Impact Bodies and General Test Procedures), or other suitable impact or abrasion tests.

Brief Description of the Drawings

FIGURE 1 is a perspective view of a single piece laminate composite comprising fiber-cement laminated to gypsum.

FIGURE 2 is a cross-sectional view of the single piece laminate composite of FIGURE 1, showing the relative thicknesses of the fiber-cement, gypsum and the adhesive layers which comprise the single piece laminate composite.

Detailed Description of the Preferred Embodiments

The preferred embodiments of the present invention illustrated below describe a single piece laminate composite wallboard system. It will be appreciated, however, that the present invention is not limited to wallboards, but can be utilized for any application where an abuse resistant, impact resistant and fire resistant building material is desired.

As seen in FIGURES 1 and 2, a preferred building material 40 is comprised of fiber-cement layer 10 laminated to gypsum layer 20 using an adhesive 30, creating a single piece laminate composite. It will be appreciated that the

fiber-cement and gypsum components can take any form necessary, including, but not limited to, panels, sheets, skins, boards, or the like. In one preferred embodiment, the thickness of a fiber-cement sheet 10 is between about 1/32" and ¼". More preferably, the fiber-cement sheet 10 is about 1/8" thick, plus or minus about 1/16". A gypsum panel 20 typically has a thickness between about ¼" to ¾", more preferably about ½". It will be appreciated that other thicknesses for the fiber-cement sheet 10 and the gypsum panel 20 may be used. The preferred density is about 2.5 to 3 lbs/square foot, more preferably about 2.77 lbs/square foot for a 5/8" thick composite wallboard.

One preferred embodiment of the invention is a composite panel that is manufactured by bonding together a paper-faced ½" type X gypsum wallboard to 1/8" thick fiber cement panel. ASTM C 36 describes a type X gypsum board to have not less than 45 minutes fire resistance rating for boards ½" thick, applied parallel with and on each side of load bearing 2" x 4" wood studs spaced 16" on center with 6D coated nail, 1-7/8" long 0.095" diameter shank, ¼" diameter head, spaced 7" on center with the gypsum joints staggered 16" on each side of the partition and tested in accordance with ASTM E 119. One preferred ½" Type X gypsum panel is a ½" thick HARDIROCK® MAX "C"™, described in the table below. This gypsum panel has an improved Type X fire resistance rated core and is manufactured for commercial projects where building codes require specific levels of fire resistance and sound reduction. The 5/8" thick board is designed to provide greater fire resistance than standard Fire X™ board and achieves fire and sound rating with less weight. Application information is available in the Gypsum Association Fire Resistance Design Manual GA-600, Underwriter's Laboratories, Inc. Fire Resistance Directory.

HARDIROCK® MAX "C"™	
THICKNESS inches (mm)	1/2" (12.7 mm)
WIDTH feet (mm)	4' (1219 mm)
STANDARD LENGTHS feet	8', 9', 10'
STANDARD EDGES	Tapered or square
APPROX WEIGHT lbs/sq ft (kg/m^2)	1.8 lbs/sq ft (8.8kg/m^2)
ASTM SPECS	C 36

It will be appreciated that the face of the gypsum panel 20 bonded to the fiber-cement 10 does not necessarily require a paper face, and the gypsum panel 20 may be bonded directly to the fiber-cement 10. A preferred gypsum panel 20 may also have a glass or polymeric fiber mat or woven mesh combined into the panel on either the front or back surface, either on the outside or the inside of the paper. This can be done for two reasons. First, it can

be used to improve the impact resistance of the gypsum panel 20 by itself. Second, it can be used to improve the impact resistance of the gypsum panel as part of the composite wallboard 40.

The preferred composite wallboard 40 can be utilized in most interior wallboard installations. The preferred composite wallboard 40 is installed such that the fiber-cement side of the wallboard 40 faces outward to provide an abrasion and indentation resistant surface to traffic, and the gypsum side of the wallboard 40 is installed against the supporting framing, with the synergistic combination of the fiber-cement and the gypsum wallboard providing the fire resistance rating and strength of the panel. Neither the preferably ½" gypsum panel 20 nor the preferably 1/8" fiber-cement sheet 10 provides the 1-hour fire resistance rating in isolation, but rather the combination of the two materials in a laminated composite 40 has been tested in a symmetrical wall system and achieved a 1 hour fire resistance rating on a typical steel framing used in commercial building partitions. Results of a fire resistance test conducted on this composite panel are provided below.

The supporting framing is typically 20 or 25 gauge steel framing, or wood framing such as 2" x 4" Douglas Fir softwood. The wallboard 40 can be fastened to the steel studs with suitable screws such as 6 gauge x 1-1/8" Type S Bugle Head drywall or self-drilling screws. The wallboard 40 can be fastened to wood studs with suitable nails or screws such as 1-3/4" long cup-head gypsum wallboard nails or 6 gauge x 1-1/8" Type S Bugle Head drywall screws. The preferred wallboard 40 is designed for use in wall assemblies that are subject to surface abuse and penetration. Such wall assemblies are typically found in schools, public housing, public buildings, interior garage walls, corridors, gymnasiums, change rooms, and correctional and healthcare facilities. The material can be cut with a carbide-tipped score and snap knife, power shears or circular saw optionally with dust control.

Fiber Cement

The art of manufacturing cellulose fiber reinforced cement for use in a fiber-cement sheet or skin 10 is described in the Australian Patent AU 515151 and U.S. Patent No. 6,030,447, the entirety of which is incorporated by reference. Fiber cement has the attributes of durability, resistance to moisture damage, low maintenance, resistance to cracking, rotting or delamination, resistance to termites and non-combustibility. Thus, the fiber cement layer 10 resists damage from extended exposure to humidity, rain, snow, salt air and termites. The layer is dimensionally stable and under normal conditions will not crack, rot or delaminate.

The basic composition of a preferred fiber-cement panel 10 is about 20% to 60% Portland cement, about 20% to 70% ground silica sand, about 5% to 12% cellulose fiber, and about 0% to 6% select additives such as mineral oxides, mineral hydroxides and water. Platelet or fibrous additives, such as, for example, wollastonite, mica, glass fiber or mineral fiber, may be added to improve the thermal stability of the fiber-cement.

The dry density of a preferred fiber-cement panel 10 is typically about 1.3 to 1.4 g/cm^3 but can be modified by pressing the material to dry densities up to 2.0 g/cm^3 or by addition of density modifiers such as unexpanded or expanded vermiculite, perlite, clay, shale or low bulk density (about 0.06 to 0.7 g/cm^3) calcium silicate hydrates.

The flexural strength of a preferred fiber-cement panel 10, typically based on Equilibrium Moisture Content in accordance with ASTM test method C1185, is 1850 psi along the panel, and 2500 psi across the panel.

A preferred fiber-cement panel 10 has a non-combustible surface and shows no flame support or loss of integrity when tested in accordance with ASTM test method E136. When tested in accordance with ASTM test method E84, a preferred fiber-cement panel 10 exhibits the following surface burning capabilities:

Flame spread: 0

Fuel Contributed: 0

Smoke Developed: 5.

<u>Lamination Process</u>

A preferred panel is comprised of a 1/8" nominal thickness fiber cement sheet laminated to a ½" thick type X fire resistant gypsum board. The gypsum panel is preferably manufactured with square edges. An adhesive 30 as shown in FIGURES 1 and 2 above such as polyvinyl acetate (PVA) is spread over the surface of the gypsum panel and 1/8" thick fiber cement is placed over the surface and is typically pressed at about 38 psi, in a stacked configuration, for approximately 30 minutes. One preferred adhesive is Sun Adhesives polyvinyl acetate (PVA) adhesive #54-3500 supplied by Sun Adhesives, a division of Patrick Industries. While the adhesive is most preferably a low cost adhesive such as PVA, other organic or inorganic adhesives may be used, such as water-based polymeric adhesives, solvent-based adhesives, thermoset adhesives, natural polymers such as modified starches, liquid moisture cure or reactive hot melt adhesives such as polyurethane, and heat or fire resistant adhesives.

The adhesive 30 is preferably applied by a roll-coater process whereby the gypsum panel 20 is preferably cleaned to remove dust and debris before the adhesive 30 is applied to the smooth face. The adhesive 30 is preferably spread evenly over the entire surface of the gypsum panel 20. The wet film thickness of the adhesive 30, when measured with a standard "wet film thickness gauge," will preferably not be less than about 4.5 mil and preferably will not exceed about 6 mil. The fiber-cement panel 10 is placed on top of the gypsum panel 20, which is coated with adhesive 30, squared to the edges of the gypsum panel 20, and then stacked. The completed stack is preferably cured in a press under a load of about 37.5 ± 2.5 psi for preferably no less than about 30 minutes. The panels then preferably have the fiber cement surface sanded and the long edges machined with an abrasive wheel such as diamond grit to form a tapered edge. The machine sanding preferably utilizes three sanding heads. The grades of sanding belts preferably range from 40 grit to 220 grit. The long edges are machine tapered to allow for setting compound, joint reinforcing tape and finishing compounds during flush jointing on installation. The surface of the product is preferably sealed with an acrylic emulsion to reduce the surface water absorption to make it easier to paint and to improve paint adhesion.

The fiber-cement surface of the composite wallboard 40 may be optionally sealed with an acrylic sealer such as UCAR 701 to facilitate on the job finishing. This can be achieved with a suitable latex paint which may be sprayed, rolled or brush applied for wallpaper or texture finishes. It will also be appreciated that sanding the fiber-cement panel 10 is optional in order to improve the finish of the fiber-cement surface. Furthermore, it will be appreciated that sanding can be done before or after the fiber-cement panel 10 is laminated to the gypsum panel 20. It will be appreciated that a roll press lamination process may also be used, with a suitable pressure sensitive adhesive.

Testing

Abuse resistance tests were conducted on one preferred laminate composite panel. This preferred panel provided superior impact resistance to the common type X fire resistant gypsum wallboard. The preferred panel also has superior abrasion resistance to both the common type X fire resistant gypsum wallboard and the abuse resistant gypsum based panels.

A novel feature of the preferred embodiments of the present invention is that neither the ½" gypsum wallboard or the 1/8" fiber cement sheet, by themselves, provide altogether, the 1-hour fire resistance rating, surface abuse and impact resistance. However, laminating the two materials together provides the 1-hour fire resistance in a symmetrical wall system when tested to ASTM E119 and an improved level of surface abuse resistance and impact resistance.

It is believed that the preferred panel also has the advantages of improved flexural strength and nail pull through strength and less humidified deflection compared to the individual components of the preferred invention or a typical type X gypsum wallboard of the same thickness (5/8" thick).

The preferred composite also has the novel features of fire and abuse characteristics in a single wallboard or a single piece system. Prior fire resistance rated and abuse resistant systems that utilize fiber cement required a two layer system over the supporting framework. There is considerable advantage with the preferred composite in reduced material and quicker installation of a single piece system versus a 2-layer system. The two layer system required installation of 5/8" type X gypsum wallboard followed by the installation of ¼" fiber cement over the top. The total thickness of these 2 layers adds up to 7/8" of material versus 5/8" of material with the preferred laminated composite of the present invention.

Thus, in one embodiment the present invention provides a single piece system that is at least about one hour fire resistance-rated and abuse resistant. This reduces the amount of time to install compared to the 2 layer system, lowers the mass of the wall unit per square foot compared to the 2 layer system, and requires less fixtures per wall for installing panel compared to the 2 layer system. Moreover, the material is easily cut with power shears, which is a quick and easy method of cutting.

The material also is abrasion resistant, indentation resistant and impact resistant (soft body and hard body), as illustrated in the tables below.

Surface-abuse and impact resistance can be determined by methods used in such tests as ASTM D 4977-98b (Standard Test Method for Granule Adhesion to Mineral Surfaced Roofing by Abrasion), ASTM D 5420 (Impact Resistance of Flat, Rigid Plastic Specimen by Means of a Striker by a Falling Weight (Gardner Impact)), ASTM E 695 (Measuring Relative Resistance of Wall, Floor and Roof Construction to Impact Loading), ISO 7892 (Vertical Building Elements - Impact Resistance Tests - Impact Bodies and General Test Procedures), or other suitable impact or abrasion tests. Fire resistance can be measured by tests such as ASTM E 119 (Standard Test Methods for Fire Tests of Building Construction and Materials), UL263, UBC 7-1, NFPA 251, ANSI A2.1, or other suitable fire resistance tests.

One 5/8" thick laminate composite embodiment, comprising 1/8" fiber-cement laminated on top of a ½ Hardirock Max "C" Gypsum panel, achieved superior abrasion and impact resistance as illustrated in the tables below.

Table 1

ASTM D4977 - Wire Brush Surface Abrasion Test
(Modified to have a total of 25 lbs load on brush)

Product	Abraded Depth (mm)	Abraded Depth (inches)
5/8" laminate composite	0.000	0.000
5/8" Type X Gypsum Board	0.016	0.001

Table 2

ISO 7892 Section 4.3 - Hard Body/Impact Resistance Test
(Single Impact @ 10 ft. Height-22 ft.-lb. force)

Product	Indentation Diameter (inches)	Indentation Depth (inches)
5/8" laminated composite	1.270	0.275
5/8" Type X Gypsum Board	1.788	0.275

The hard body impact test was conducted with a 1 kg ball bearing as outlined in Section 4.3.1 through 4.3.5 of ISO 7892.

The panels tested were fastened to 20 gauge steel framing with studs at 16" on center. The ¼" fiber cement panel was fastened with 7 gauge x 1-1/4 C-Drill screw spaced at 8". The 5/8" Type X gypsum wallboard was fastened with 6 gauge x 1-1/8" Type S Bugle Head screws spaced at 8" and the 1/8" fiber cement laminated on top of ½" Hardirock Max "C" gypsum wallboard was fastened with 6 gauge x 1-1/8" Type S Bugle Head screws spaced at 12".

Table 3

ASTM D5420 - Indentation Test/Gardner Impact Test

Product	Indentation Depth (inches)
5/8" laminated composite	0.101
5/8" Type X Gypsum Board	0.149

For the indentation test, ASTM D5420-96 Method GC was followed which specifies a 0.625 mm diameter striker orifice with a support plate hole close to the diameter of the striker, and a 2 lb. weight falling a distance of 36

inches giving a single energy impact of (72 ± 1.8) ft.-lbs. Ten specimens were tested from each product and values in the table have been averaged for all 10.

Table 4

ASTM E695-79 - Soft Body Impact Resistance Test

Product	Cumulative Impact Force (ft.-lbs.)	Single Impact Force (ft.-lbs.)
5/8" laminated composite	180	210
5/8" Type X Gypsum Board	60	90
¼" Fiber-cement Panel	60	90

The soft body impacter was fabricated according to the requirements of sections 5.2.1 through 5.2.4 of E695-79, filled to a gross weight of 60 lbs. The bag is supported as a pendulum, striking the panel midway between the stud and mid height of the test wall in 6" increments.

The cumulative impact was defined as the energy needed to reach "failure mode" either by "set deflection", face/back cracking, and/or stud deformation of > 0.25". Upon reaching any of the previously defined failure mode(s), the weighted bag was raised an additional 6 inches in height to reach the "single impact energy" needed to reach a failure mode.

The cumulative impact was defined as the energy needed to reach "failure mode" either by: "set deflection", and face / back cracking, and/or stud deformation of > 0.25". Upon reaching any of the previously defined failure mode(s), the weighted bag was raised an additional 6 inches in height to reach the "single impact energy" needed to reach a failure mode.

The size of the panels was 4' x 8', and were fastened to 20-gauge steel framing at 24" on center. The ¼" fiber cement panel was fastened with 7 gauge x 1-1/4 C-Drill screw spaced at 8". The 5/8" Type X gypsum wallboard was fastened with 6 gauge x 1-1/8" Type S Bugle Head screws spaced at 8" and the 1/8" fiber cement laminated on top of ½" Hardirock Max "C" gypsum wallboard was fastened with 6 gauge x 1-1/8" Type S Bugle Head screws spaced at 12".

Results in the table are an average of 3 panels of each material tested.

Fire Resistance Testing

One embodiment of the present invention was tested for fire resistance according to ASTM E 119-98. This embodiment was tested as a dual wall assembly, comprising a cold side and hot side. Each test assembly consisted of a 10 ft x 10 ft non-loadbearing wall of 20 GA x 3-5/8" steel studs spaced 24" o.c. On the cold side, one layer of 1/8" thick Hardiboard® fiber-cement face skin laminated to ½" thick Hardirock® "Max C"™ gypsum board was applied perpendicular (horizontally) to 20 GA. x 3-5/8" steel studs 24" o.c. with minimum 1" long Type S drywall screws 12"

o.c. at floor and ceiling runners and intermediate studs. Fasteners were placed approximately 3" in from panel corners and approximately 3/8" in from panel edges. On the fire side, one layer of 1/8" thick Hardiboard® fiber-cement face skin laminated to ½" thick Hardirock® "Max C"™ gypsum board was applied perpendicular (horizontally) to 20 GA. x 3-5/8" steel studs 24" o.c. with minimum 1" long Type S drywall screws 12" o.c. at floor and ceiling runners and intermediate studs. Fire side horizontal panel joints were offset from cold side horizontal panel joints by 24". Fasteners were placed approximately 3" in from framing corners and approximately 3/8" in from panel edges.

Framing members in fire-rated wall assemblies are cut ¾" shorter than full height of wall thereby creating a floating frame wall. In order to transport these walls from the fire test facility to the sound test facility, fasteners were placed through the wall panels into framing members at floor and ceiling runner tracks to provide racking resistance to facilitate specimens handling. This modification does not change the sound transmission characteristics of the wall assembly.

Joints were treated with chemically-setting powder gypsum joint compound (USG® Durabond® 90), complying with ASTM Specification C 475, for flush joining the panel edges. Setting-type compound was mixed in accordance with manufacturer's written instructions. Compound was applied to fastener heads and joint recess was formed by adjoining sheets. Perforated paper reinforcing tape was immediately imbedded centrally into the joints. Perforated paper reinforcing tape was immediately imbedded with additional compound and allowed to dry.

The ambient temperature at the start of the test was 80° F, with a relative humidity of 84%. Throughout the fire test, the pressure differential between the inside of the furnace (measured at a point 1/3 of the way down from the top center of the wall specimen) and the laboratory ambient air was maintained at –0.03 inches of water column, which resulted in a neutral pressure at the top of the test article.

Observations made during the test were as follows:

Time (min:sec)	Observation
0:00	Furnace fired at 8:52 a.m.
1:43	Applicant's laminated composite panel separating out-of-plane (OOPS) at top horizontal joint on the fire side
2:20	Surface of Applicant's laminated composite panel cracking and turning black
3:25	Laminate peeling and falling off exposed surface
4:15	Much of the laminate has fallen away; exposed gypsum paper flaming
7:13	Gypsum paper black/gray and flaking on fire side
10:30	All of the laminate has fallen off exposed surface
32:30	~1/8" gap at the bottom horizontal joint on the exposed side
39:00	~1/2" OOPS at the bottom horizontal joint near center of wall on the exposed side.
60:00	The furnace was extinguished and the test article removed and exposed to the standard hose stream test.

Hose Stream	The wall was exposed to the standard hose stream test for at a pressure of 30 psi from 20 feet away from the exposed surface for a period of 60 seconds. The test article failed the hose stream test when the hose stream penetrated the wall after 19 seconds.

During the fire test, the wall was measured for deflection at three points along its vertical centerline: at 30" (position #1), 60" (position #2) and 90" (position #3) from the left side of the wall. Measurements were made from a taut string to the wall surface at each location.

TIME (min)	Position #1 (in.)	Position #2 (in.)	Position #3 (in.)
0	5-3/8	5-3/8	5-1/2
10	5-5/8	5-5/8	5-7/8
20	6-1/4	6-1/2	6-1/2
30	6-3/4	6-3/4	6-7/8
40	6-1/2	6-1/4	6-1/2
50	6-1/4	5-7/8	6-1/4
60	6-1/4	6	6-1/2

Hose Stream Retest

In accordance with the standard, a duplicate specimen was subjected to a fire exposure test for a period equal to one half of that indicated as the resistance period in the fire endurance test, immediately followed by the hose stream test.

Observations made during the test were as follows:

Time (min:sec)	Observation
0:00	Furnace fired at 1:37 p.m.
0:53	Applicant's laminated composite panel cracking on the exposed side
1:20	Applicant's laminated composite panel turning black
2:40	Gypsum paper turning brown where laminate has fallen off
3:00	Exposed gypsum paper ignited
4:25	Exposed gypsum paper stopped flaming
11:00	Much of the laminate is gone, gypsum paper turning white
30:00	The furnace was extinguished and the test article removed and exposed to the standard hose stream test.
Hose Stream	The wall was exposed to the standard hose stream test for 60 seconds at a pressure

Time (min:sec)	Observation
	of 30 psi from 20 feet away from the exposed surface. The test article withstood the hose stream test without allowing passage of water through the wall.

Conclusions from Fire Testing

The 20 GA., 3-5/8" galvanized steel stud wall with Applicant's laminated composite panels (1/8" thick Hardiboard® fiber-cement face skin laminated to ½" thick Hardirock® "Max C"™ gypsum wallboard) on both surfaces, constructed and tested as described in this report, achieved a non-loadbearing fire resistance rating of 60 minutes for a symmetrical wall assembly according to the ASTM E119 standard.

Summary of Advantages

The preferred embodiments of the present invention combine fire resistance of at least 1 hour and significant abuse and impact resistance in a prefabricated single piece laminate composite comprising fiber-cement laminated to gypsum. These properties are achieved in a laminate composite which in one embodiment is only about 5/8" thick that is not excessively heavy, is easy to cut and is quick and easy to install.

One disadvantage of the two layer systems of the prior art is that the individual pieces of fiber-cement and gypsum must be self-supporting in order to facilitate their individual installation. The layers of fiber-cement and gypsum, therefore, are limited in how thin they can be in order to remain self-supporting. The preferred embodiments of the present invention, however, combine the fiber-cement and gypsum layers into a prefabricated single piece laminate composite for installation. Thus, the individuals layers of fiber-cement and gypsum need not be self-supporting, and the thickness of the fiber-cement layer, for instance, can be significantly reduced. This reduces the overall thickness of the single piece laminate composite as compared to the two piece systems. As a result, one embodiment of the present invention incorporates a 1/8" fiber-cement layer and a ½" gypsum layer to create a single piece laminate composite about 5/8" thick, that simultaneously achieves a one hour fire resistance rating and abuse and impact resistance.

The embodiments illustrated and described above are provided merely as examples of certain preferred embodiments of the present invention. Various changes and modifications can be made from the embodiments presented herein by those skilled in the art without departing from the spirit and scope of the invention.

WHAT IS CLAIMED IS:

1. A building material comprising:

a fiber-cement sheet; and

a gypsum panel, wherein the fiber-cement sheet is laminated to the gypsum panel to form a single piece laminate composite having a fire resistance rating of at least one hour according to ASTM E 119.

2. The building material of Claim 1, wherein the single piece laminate composite has a thickness of about 5/8 inch.

3. The building material of Claim 2, wherein the fiber-cement sheet has a thickness of about 1/8 inch.

4. The building material of Claim 2, wherein the gypsum panel has a thickness of about ½ inch.

5. The building material of Claim 1, wherein the fiber-cement sheet is adhered to the gypsum panel with an adhesive layer between about 4.5 mil and 6 mil thick.

6. The building material of Claim 1, wherein the fiber-cement sheet is adhered to the gypsum panel with an adhesive of polyvinyl acetate.

7. The building material of Claim 1, wherein the single piece laminate composite is roll-pressed.

8. The building material of Claim 1, wherein the single piece laminate composite is pressed in a single or stacked configuration.

9. The building material of Claim 1, wherein at least one surface of the single piece laminate composite is sealed with a polymeric water-based emulsion or solvent-based sealant.

10. The building material of Claim 1, wherein at least one surface of the single piece laminate composite is primed with a water-based or solvent-based paint.

11. A building material, comprising:

a fiber-cement layer; and

a gypsum layer, wherein the gypsum layer is laminated to the fiber-cement layer to form a single piece laminate composite.

12. The building material as recited in Claim 11, wherein the single piece laminate composite has a fire resistance rating greater than that of either the fiber-cement layer or the gypsum layer individually.

13. The building material as recited in Claim 11, wherein the single piece laminate composite has a thickness of about 5/8 inch.

14. The building material as recited in Claim 13, wherein the fiber-cement layer has a thickness of about 1/8 inch.

15. The building material as recited in Claim 13, wherein the gypsum layer has a thickness of about ½ inch.

16. The building material as recited in Claim 11, wherein the fiber-cement layer is laminated to the gypsum layer with an adhesive that is between about 4.5 mil and 6 mil thick.

17. The building material as recited in Claim 11, wherein the fiber-cement layer has a thickness such that the fiber-cement layer individually is not self-supporting.

18. A method for preparing a building material for installation comprising laminating a fiber-cement layer to a gypsum panel to form a single piece laminate composite.

19. The method of Claim 18, wherein the fiber-cement layer is laminated to the gypsum panel using a polyvinyl acetate adhesive.

20. The method of Claim 18, wherein laminating the fiber-cement layer to the gypsum panel includes pressing the fiber-cement layer to the gypsum panel at a pressure of at least 38 psi.

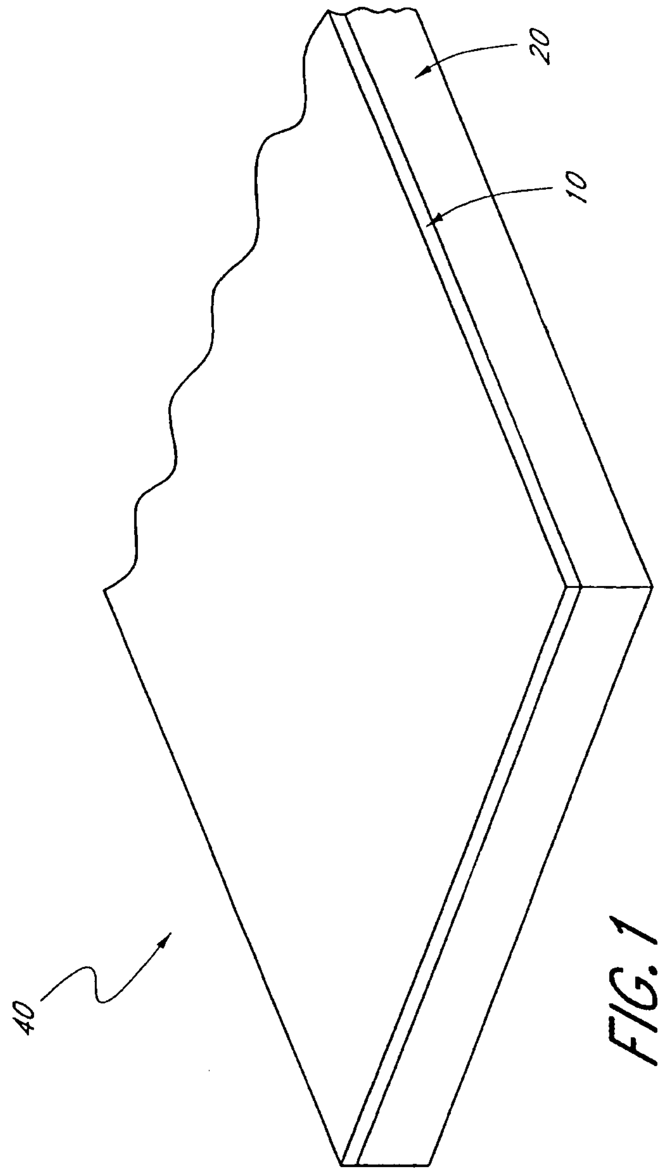

FIG. 1

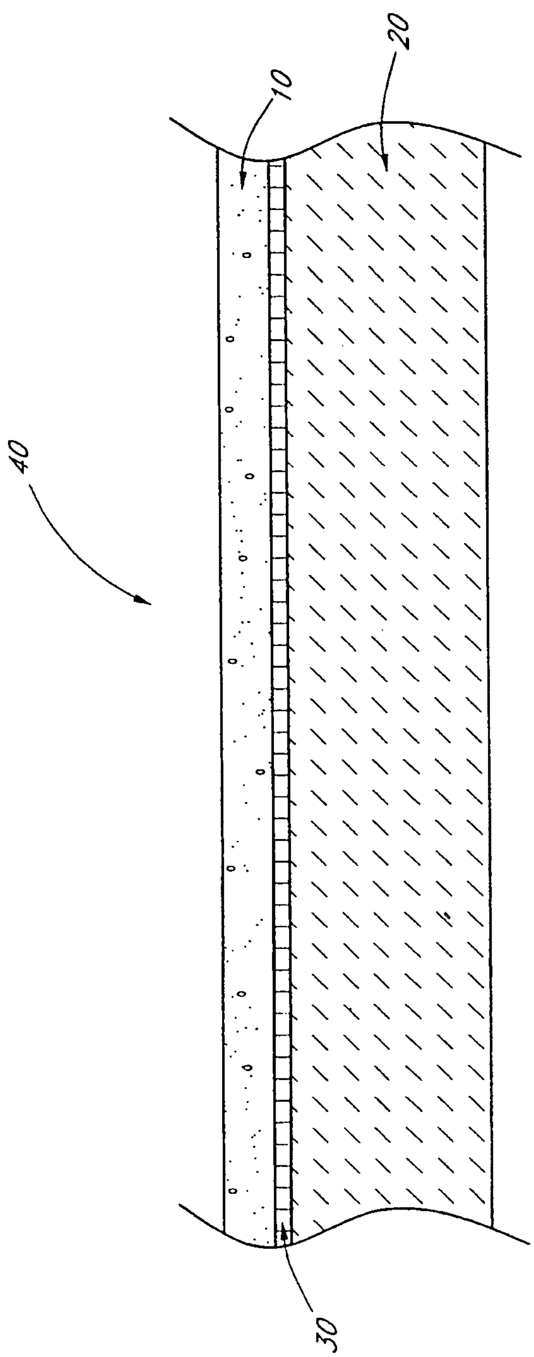

FIG.2

INTERNATIONAL SEARCH REPORT

International Application No
PCT/US 00/27451

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 B32B13/00 E04B1/94

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 B32B E04C E04B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 4 361 616 A (BOEMERS JOSEPH J P) 30 November 1982 (1982-11-30) column 1, line 57 -column 2, line 26; claims 1,9,6 ---	1,3,4, 11,14, 15,17,18
X	DATABASE WPI Section Ch, Week 197723 Derwent Publications Ltd., London, GB; Class A13, AN 1977-40569Y XP002159268 & JP 52 051719 A (KANEBO LTD), 25 April 1977 (1977-04-25) abstract --- -/--	1,11,18

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
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Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Ibarrola Torres, O

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INTERNATIONAL SEARCH REPORT

Int tional Application No
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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	DATABASE WPI Section Ch, Week 197723 Derwent Publications Ltd., London, GB; Class A93, AN 1977-40665Y XP002159269 & JP 52 052429 A (KANEBO LTD), 27 April 1977 (1977-04-27) abstract ---	1,11,18
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INTERNATIONAL SEARCH REPORT

Information on patent family members

Int tional Application No
PCT/US 00/27451

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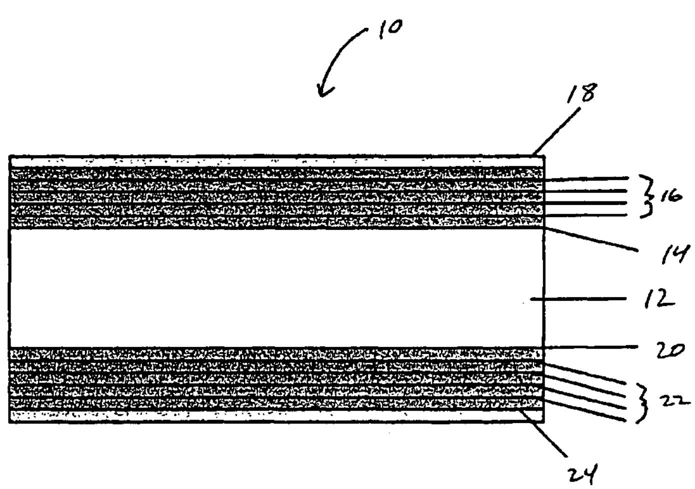
[Continued on next page]

(54) Title: PREFABRICATED DURABLE BUILDING MATERIAL



(57) Abstract: A pre-finished, moisture resistant and durable building material is provided. In one embodiment the building material includes a fiber cement substrate having a first side and a second side, at least one resin impregnated paper over at least one of the first and second sides, and a stress-relieving polymeric film between the fiber cement substrate and the at least one resin impregnated paper, the polymer film acting as a stress relaxer between the fiber cement substrate and the at least one resin impregnated paper. In another embodiment, a stress-relieving polymeric coating or film is provided between resin penetrated sheets and a substrate. In another embodiment, a process for bonding the resin penetrated sheets to the substrate is provided.

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IT, LU, MC, NL, PT, SE, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

Published:

— *With international search report.*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

PREFABRICATED DURABLE BUILDING MATERIAL

Background of the Invention

Field of the Invention

This invention relates to building materials, and more particularly, to a building material comprising a fiber cement substrate, a polymer film and a plurality of resin impregnated sheets that is both pre-finished and durable.

Description of the Related Art

Fiber cement in recent years has become popular for use as a building material instead of more conventional materials such as wood, metal and plastics. Fiber cement has better water resistance than wood and is more resistant to rotting, cracking or splitting than wood. Also, fiber cement does not rust like metal, and is more durable to weathering than plastics. For instance, fiber cement products such as James Hardie Building Products' HARDIPLANK® install just as easily as wood siding, but offer a lifetime of low maintenance. Fiber cement siding is a durable, attractive alternative to traditional wood composite, cedar, vinyl, brick or stucco sidings.

Despite these advantages, fiber cement may not always have the desired exterior look and feel for a particular application. Moreover, conventional fiber cement materials are often painted or subject to other types of post-production or on-site finishing to give the material its desired appearance and exterior protection. However, exposure of paint to natural weathering and other factors can lead to chalking of the surface and loss of polymer in the paint film. Paint surfaces are also very thin, generally on the order of one to two mils, and because of that are subject to chipping, peeling and scratching from surface abuse.

Laminates comprised of a core having a sheet laminate comprised of a plurality of resin impregnated paper sheets adhered to the core are known in the art. Known core materials include engineered wood panels such as MDF (medium density fiber board) and particle boards. These products may perform satisfactorily in dry areas, but in areas subject to moisture these products have a tendency to swell, which misaligns the edges of the structure.

U.S. Patent No. 5,425,986 discloses a laminate structure comprising a core of fiber cementboard laminated to resin impregnated sheets. The differential dimensional movement of the core and the laminate through various environmental conditions can lead to induced stresses between the fiber cement and resin impregnated sheets which often leads to splitting of the core or delamination. This is exaggerated by environments which experience high moisture followed by periods of dryness or heat and low humidity.

Accordingly, what is needed is a building material incorporating the durability and moisture resistance of fiber cement while also having a desired exterior look and feel. In addition, what is needed is a building material having an exterior surface that is pre-finished and durable to scratch and wear, while also maintaining strong adhesion to the fiber cement, and does not split, crack or delaminate when exposed to severe environmental conditions or wet/dry cycling.

Summary of the Invention

One embodiment of the present invention relates to a building material comprising a fiber cement substrate having a first side and a second side, at least one resin impregnated paper over at least one of the first and second sides, and a stress-relieving polymeric film between the fiber cement substrate and the at least one resin impregnated paper, the polymer film acting as a stress relaxer between the fiber cement substrate and the at least one resin impregnated paper.

In another embodiment, a film for joining fiber cement to a resin penetrated paper is provided. This film comprises a polymer adapted to balance stresses between the fiber cement and the resin penetrated paper.

In another embodiment, a method is provided for bonding a fiber cement substrate having a surface to at least one resin impregnated paper to form a building material. The method comprises coating at least a portion of the surface of the fiber cement substrate with a stress-relieving polymer film, the polymer film being capable of preventing delamination between the substrate and the at least one resin impregnated paper. The at least one resin impregnated paper is pressed against the polymer film and the substrate.

Brief Description of the Drawings

FIGURE 1 is a cross-sectional view of a building material incorporating a fiber cement core having a plurality of resin impregnated papers laminated thereto according to one embodiment of the invention.

Detailed Description of the Preferred Embodiments

The preferred embodiments of the present invention relate to a pre-finished, moisture resistant and durable building material, preferably comprising laminating fiber cement to one or a plurality of resin penetrated papers or sheets such as FORMICA®. In one embodiment, a pre-finished and durable building material is provided. In another embodiment, a polymeric coating or film is provided between resin penetrated sheets and a substrate. In another embodiment, a process for bonding the resin penetrated sheets to the substrate is provided.

The pre-finished building material preferably combines three components: (1) a substrate, (2) a polymer film or coating, and (3) resin penetrated papers. These components formed together provide a building construction material that is both pre-finished and durable. The resin penetrated papers may be provided on either one side of the substrate or both sides.

The substrate is most preferably fiber cement, but may also be wood, metal such as aluminum, concrete or other cementitious material, plastic such as polyvinyl chloride, composite material such as fiber reinforced plastics, engineered wood material such as hardboard or oriented strand board and gypsum board. In one embodiment, the fiber cement substrate is about 20% to 60% Portland cement, about 20% to 70% ground silica sand, about 0% to 12% cellulose fiber, and about 0% to 6% select additives such as mineral oxides, mineral hydroxides and water. Platelet or fibrous additives, such as, for example, wollastonite, mica, glass fiber or mineral fiber, may be added to improve the thermal stability of the fiber cement. The dry density fiber cement sheet is typically about 1.3 to 1.4 g/cm^3 but can be modified by pressing the material to dry densities up to 2.0 g/cm^3 or by addition of density modifiers such as

unexpanded or expanded vermiculite, perlite, clay, shale or low bulk density (about 0.06 to 0.7 g/cm^3) calcium silicate hydrates or aeration.

The polymeric film is preferably polyurethane, acrylic, acrylic-styrene, polyester, polyether, polyvinyl and their modified films. Other films that may be used include but are not limited to films formed from thermosetting polymers and thermoplastic polymers, such as epoxy, polyamide, polyimide, polysulfide, silicon based polymer, natural polymers such as starch. The film may be an individual film with or without an adhesive on its surface, or may be a film formed from water based solution, solvent based solution or 100% solid polymers. In one embodiment, the thickness of the film is from about 0.2 mil to 5 mil.

The polymeric film is preferably flexible, with a glass transition temperature T_g preferably between about -90°C and 50°C, more preferably below 0°C, with good strength. The polymeric film advantageously has good adhesion to both fiber cement and resin penetrated sheets such as FORMICA®. Alternatively, when a separate adhesive is placed on one or both sides of the polymeric film, this adhesive should have good adhesion to the fiber cement and/or resin penetrated sheet.

The cellulose paper is preferably penetrated with resin of melamine-formaldehyde and phenol-formaldehyde, and may also be treated by other polymer resins, such as polyester. The thickness of the penetrated paper in one embodiment is from about 0.05 mm to 1 mm. The amount of resin in the paper is preferably from about 10% to 70%.

The process is preferably to laminate the resin penetrated papers, the polymer film and the substrate together all at the same time (direct method). Another process that may be used laminates the resin penetrated papers first, and then laminates this sheet of laminated papers, the polymer film and the substrate together (indirect method).

The invention relates in one embodiment to laminating resin impregnated papers such as FORMICA® to a fiber cement core. Lamination may occur at different pressures, and may be accomplished by direct and indirect lamination as discussed above. The invention also relates to the product of FORMICA® or similar materials laminated to fiber cement.

One problem experienced with laminating resin impregnated papers to fiber cement without a specially selected polymeric film is that the laminate suffers from delamination. For instance, after melamine-formaldehyde (MF) and phenol-formaldehyde (PF) impregnated papers are pressed in a pressure machine, the resin will cure and the lamination will have a much larger dimensional movement than the fiber cement panel under heat and moisture. Because of the differential movement, the lamination of resin impregnated paper to fiber cement will delaminate under dry conditions, high humidity or with heating up as the forces on the material tear the lamination apart.

The preferred embodiments of the present invention overcome this problem by developing a method to treat the surface of fiber cement by using a polymer coating or film to successfully stop the delamination on FORMICA® laminated fiber cement whether the product is made from direct or indirect lamination. The polymer coating is preferably a non-rigid, stress-relieving material, and is more preferably an elastomeric material, even more preferably having the properties described above, that acts as a stress relaxer to relieve the stress between the fiber cement and

the resin impregnated sheets. Laminates incorporating this coating are less susceptible to delamination and/or splitting or cracking.

Optionally, the fiber cement substrate may be pressed flat in the green state or sanded after curing to obtain a smooth surface on which a minimal number (e.g., 1 or 2) of resin impregnated papers may be bonded incorporating a coating, as described above. By machining or sanding the surface smooth prior to coating, this enables a fewer number of resin impregnated papers to be used to obtain the desired flat finish. Such product has the differential stresses between the fiber cement and the resin impregnated papers more adequately balanced to resist cracking or splitting of the core.

FIGURE 1 illustrates one embodiment of a building material constructed in accordance with the present invention. This building material 10 includes a substrate 12, which in one embodiment is a fiber cement panel, the panel 12 having a first side and a second side. On the first side of the panel 12, a first layer of elastomeric adhesive 14 is provided, such as described above. A plurality of resin impregnated papers 16 is preferably provided over the elastomeric adhesive 14. In the embodiment shown, four layers 16 of phenol-formaldehyde impregnated papers are provided. Over the layers 16 a layer of melamine-formaldehyde penetrated paper 18 is preferably provided.

On the second side of the panel 12, a second layer of elastomeric adhesive 20 is provided. As with the first side, in one embodiment a plurality of resin impregnated papers 22, more preferably four layers of phenol-formaldehyde impregnated papers, are provided over the second layer of elastomeric adhesive 20. A layer of melamine-formaldehyde penetrated paper 24 is preferably provided over the layers 22.

The elastomeric material used for the adhesives 14, 20 preferably can be stretched and pressed without damaging the elastomeric material under limited force. The elastomeric material preferably recovers to its original shape after relieving of the force. In one embodiment, the elastomeric material used has an elongation between about 20% and 1200%, more preferably between about 100% to 1000%. The modulus of elasticity of the material at 100% elongation is preferably between about 10 to 10,000 psi, more preferably about 50 to 8,000 psi.

It will be appreciated that the embodiment shown in FIGURE 1 is purely exemplifying, and thus, other types of resin impregnated papers in varying quantities may be provided. Thus, in one embodiment, resin impregnated papers may be provided only to one side of the panel 12. In addition, each side may preferably have a fewer number or larger number of phenol-formaldehyde penetrated papers, for example, 0 to 4. In the embodiment above, it will also be appreciated that additional layers of melamine-formaldehyde penetrated papers may be provided, for example 1 to 3.

Further examples of a building material 10 similar to that shown in FIGURE 1 are described below.

Example 1

One example of a building material using a direct lamination method according to this invention is herein described. A fiber cement panel having a thickness of ¼" is roller-coated with Bayhydrol PR 240 (40% of solid) on both sides of the panel. Bayhydrol 240 PR is a water-based polyurethane elastomeric adhesive available from Bayer Corp. of Pittsburgh, PA. One layer of melamine-formaldehyde (MF) resin impregnated paper and four layers of phenol-

formaldehyde (PF) impregnated papers are put on top of the coated fiber cement panel, and one layer of MF impregnated paper and one layer of PF impregnated paper is put on the bottom of the coated fiber cement. The layers and the panel together are pressed at 350°F for 5 min at pressure of 750 psi. The laminated panel is then placed in an oven of 60°C for 3 days.

The resulting building material showed no delamination. A building material fabricated in accordance with the embodiments described above was subjected to three types of delamination tests:

1. The building material was placed in a room temperature desiccate (humidity less than 10%) for 2 days.

2. The building material was placed in a dry oven at 60°C for 3 days.

3. The building material was subjected to 5 dry/wet cycles, such as 24 hours in an oven at 60°C and 24 hours soaked in water.

It has been found that when no polymer film is placed between the fiber cement and FORMICA®, delamination occurs in about 2 hours in an oven at about 60°C. With the film, no delamination occurred under the above-described three tests.

Example 2

Another example uses an indirect lamination method for laminating decorative paper to fiber cement. The phenol-formaldehyde impregnated papers and melamine-formaldehyde impregnated papers were pressed in hot press with high pressure (for example, about 1500 psi) or with medium pressure (for example, about 1000 psi) to get paper based decorative laminates. The thickness of the paper based laminate may vary from about 0.5 mm to 3 mm.

A fiber cement sheet having a thickness of about ¼" was coated with WC-0682-M-449 adhesive (H.B. Fuller, St. Paul, Minnesota) by using a brush. WC-0682-M-449 is a water-based acrylic elastomeric adhesive. The solid percentage of the adhesive was about 48%. The amount of glue on fiber cement was about 7 g/ft^2 (wet based weight, i.e. 7 g of 48% adhesive) for each side. A thickness of about 0.5 mm of paper based laminate was put on both sides of the coated fiber cement. The paper based laminates and fiber cement core were pressed at about 50 psi for about 1 min. The temperatures of top platen and bottom platen in the press were about 350°F.

The laminated panel was then placed in different environment conditions for testing adhesion and delamination. The laminated panel showed excellent adhesion and had no delamination. As a comparison, instead of using an elastomeric adhesive, urea-formaldehyde adhesive, such as described in U.S. Patent No. 5,425,986, was used to make the same laminates. Delamination occurred at the fiber cement core when the laminate was dried in oven of 60°C for about 2 hours.

In general, the preferred embodiments of the present invention enable a building material to take advantage of the durability and other properties of fiber cement while pre-finishing the material by laminating the fiber cement to resin impregnated sheets such as FORMICA® or similar material. The pre-finished surface eliminates the need for painting, either at the building construction site or paint priming and/or paint finishing coating in the factory.

FORMICA® and similar materials have the advantage over common interior and exterior house paints (such as acrylic paints) of being more durable to surface scratch and wear. Moreover, the elastomeric polymer film between the fiber cement and the FORMICA® or similar material relieves stresses therebetween and prevents delamination of the building material.

The embodiments illustrated and described above are provided merely as examples of certain preferred embodiments of the present invention. Various changes and modifications can be made from the embodiments presented herein by those skilled in the art without departure from the spirit and scope of the invention.

WHAT IS CLAIMED IS:

1. A building material, comprising:

a fiber cement substrate having a first side and a second side;

at least one resin impregnated paper over at least one of said first and second sides; and

a stress-relieving polymeric film between said fiber cement substrate and said at least one resin impregnated paper, said polymer film acting as a stress relaxer between said fiber cement substrate and said at least one resin impregnated paper.

2. The building material of Claim 1, wherein the fiber cement substrate comprises cellulose fibers.

3. The building material of Claim 1, wherein the polymeric film is selected from the group consisting of polyurethane, acrylic, acrylic-styrene, polyester, polyether, polyvinyl and their modified films, epoxy, polyamide, polyimide, polysulfide, silicon based polymer and natural polymers.

4. The building material of Claim 1, wherein the polymeric film is an elastomer.

5. The building material of Claim 4, wherein the elastomer has an elongation between about 20% and 1200%.

6. The building material of Claim 5, wherein the elastomer has an elongation between about 100% and 1000%.

7. The building material of Claim 4, wherein the elastomer has a modulus of elasticity at 100% elongation of between about 10 and 10,000 psi.

8. The building material of Claim 7, wherein the elastomer has a modulus of elasticity at 100% elongation of between about 50 and 8,000 psi.

9. The building material of Claim 1, wherein the polymeric film has a glass transition temperature between about -90 and 50°C.

10. The building material of Claim 4, further comprising an adhesive on a surface of the polymer film.

11. The building material of Claim 1, wherein the resin impregnated paper includes a cellulose paper penetrated with resin selected from the group consisting of melamine-formaldehyde and phenol-formaldehyde.

12. The building material of Claim 1, wherein a resin impregnated paper is laminated to both said first and second sides.

13. The building material of Claim 1, comprising at least one layer of phenol-formaldehyde penetrated paper over the first side of the fiber cement substrate, and at least one layer of melamine-formaldehyde penetrated paper over the at least one layer of phenol-formaldehyde penetrated paper.

14. A film for joining fiber cement to a resin penetrated paper, comprising a polymer adapted to balance stresses between the fiber cement and the resin penetrated paper.

15. The film of Claim 14, wherein the polymer is selected from the group consisting of polyurethane, acrylic, acrylic-styrene, polyester, polyether, polyvinyl and their modified films, epoxy, polyamide, polyimide, polysulfide, silicon based polymer and natural polymers.

16. The film of Claim 14, wherein the polymer is a water based polyurethane elastomeric adhesive.

17. The film of Claim 14, wherein the polymer is a water based acrylic elastomeric adhesive.

18. A method for bonding a fiber cement substrate having a surface to at least one resin impregnated paper to form a building material, the method comprising:

coating at least a portion of the surface of the fiber cement substrate with a stress-relieving polymer film, the polymer film being capable of preventing delamination between the substrate and the at least one resin impregnated paper; and

pressing at least one resin impregnated paper against the polymer film and the substrate.

19. The method of Claim 18, wherein the fiber cement has a thickness of about ¼".

20. The method of Claim 18, wherein the at least one resin impregnated paper includes a plurality of resin impregnated papers.

21. The method of Claim 20, further comprising pressing the plurality of papers together prior to pressing said papers against the polymer film and the substrate to form a paper-based laminate.

22. The method of Claim 21, wherein the paper-based laminate has a thickness of between about 0.5 mm to 3 mm.

23. The method of Claim 21, wherein pressing the plurality of papers together takes place at about 350°F for about 1 minute at a pressure of about 50 psi.

24. The method of Claim 18, wherein pressing occurs at about 350°F for about 5 minutes at a pressure of about 750 psi.

25. The method of Claim 24, further comprising, after pressing, heating the building material at about 60°C for about 3 days.

26. The method of Claim 18, further comprising smoothening the surface of fiber cement prior to coating.

27. The method of Claim 18, wherein the polymer film is elastomeric.

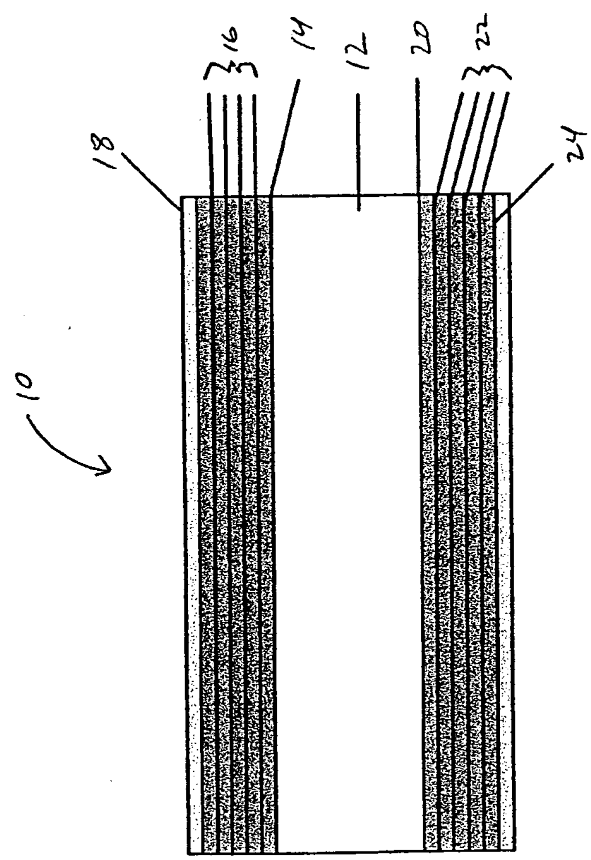

FIG. 1

INTERNATIONAL SEARCH REPORT

Int ional Application No
PCT/US 00/31729

A. CLASSIFICATION OF SUBJECT MATTER
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According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
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Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 425 986 A (GUYETTE JOHN M) 20 June 1995 (1995-06-20) column 2, line 42 - line 45 column 3, line 35 -column 4, line 26 column 6, line 15 - line 20 column 7, line 27 - line 46 ---	1-3,11, 12,14, 15, 18-22,24
A	GB 2 078 611 A (HELLENIC IND TECH COMM) 13 January 1982 (1982-01-13) page 1, line 29 -page 2, line 74 -----	1-27

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
21 February 2001	02/03/2001

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Stinchcombe, J

Form PCT/ISA/210 (second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

Information on patent family members

Int. ional Application No
PCT/US 00/31729

Patent document cited in search report		Publication date	Patent family member(s)			Publication date
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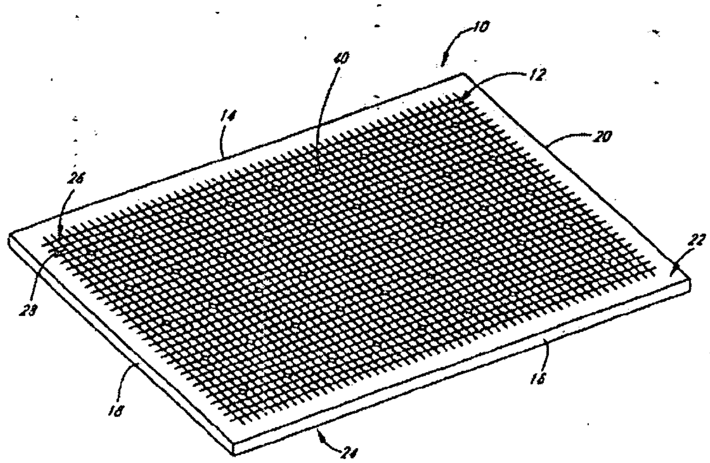
[Continued on next page]

(54) Title: SURFACE GROOVE SYSTEM FOR BUILDING SHEETS



(57) Abstract: The present invention involves building sheets with a plurality of grooves indented into a surface of the building sheet to provide a guide for cutting the building sheet along the grooves. Preferably, the grooves are arranged in a regularly repeating pattern and are spaced apart by a standard unit of measurement in order for a cutter to accurately size the building sheet to a precise dimension. A simple scoring knife is preferably used to score the sheet along the grooves, without the need for a straight edge, and the sheet is broken by simply bending the sheet of along the score mark. The grooves are preferably provided at a depth into the surface the sheet such that they do not substantially decrease the strength of the sheet or affect off-groove scoring. Thus, a score mark can be made between or across grooves without deflection of the mark into a groove and without breakage of the sheet along a groove when the sheet is bent.

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SURFACE GROOVE SYSTEM FOR BUILDING SHEETS

Background of the Invention

Field of the Invention

This Invention relates to a method, apparatus and article enabling quickly and more easily cutting, breaking and installing building sheets, and more particularly, to building sheets having a surface groove system to guide a cutter without the need for a straight edge.

Description of the Related Art

Building sheets made of fiber cement and other materials are often used as backerboards for floors, countertops, walls, etc. For instance, backerboards for ceramic tiles are used for countertops to provide the water resistant, relatively rigid, dimensionally-stable foundation over which the tile is bonded during the installation. Conventionally, the backerboard is laid over an exterior grade sheet of plywood ½ to 1 inch thick and adhered thereto using an adhesive such as a dry-set portland cement mortar or latex-modified portland cement mortar thinset. The backerboard is also fastened to the plywood subfloor using nails or screws. Once the backerboard is in place, ceramic tile is laid over the backerboard and adhered thereto using a modified thinset or other suitable tile adhesives. Backerboards are installed in a similar manner for a number of other applications, such as tile backer for floor installations and wallboard installations where the material is installed direct to stud or exterior sheathing or paneling applications.

For these and other applications, building sheets must generally be sized and cut to an appropriate dimension for installation. For instance, tile backerboards must be appropriately sized and cut before placement over plywood subfloor. This can be a time consuming and labor-intensive process, requiring a number of different tools and great precision to size and cut a board to the desired dimension. Cutting of a backerboard typically requires using a straight edge and scoring knife to score the backerboard on one side, and then snapping the backerboard up against the edge of the straight edge to break the board along the score mark. It is often difficult (particularly for long cuts) to hold the straight edge in a fixed relationship to the material with one hand, and perform the scoring or cutting with the other hand. Resultant slippage can reduce the accuracy of the resulting cut. Alternatively, a circular saw with a carbide tipped blade or shears have also been used to cut backerboards.

To assist in determining a desired cut location, backerboards have been known to contain marker locations, for example markers 6 inches apart marked in ink, to indicate fastening locations for nails or drills. These markers can also provide a visual aid to enable a cutter to more easily locate a desired cutting location. U.S. Patent No. 5,673,489 to Robell describes a gridded measurement system for construction materials such as wallboards wherein a plurality of horizontal and vertical unit measurement markings are positioned around the perimeter of the construction material surface to provide quick dimensional reference for sizing of the construction material. The construction material surface is filled with horizontal and vertical grid markings between the numbered unit measurement markings.

Construction boards with markings as described above, though generally assisting in visualizing cut locations, still do not significantly decrease the time and labor for installation. This is due in part to the fact that boards with markings still require the use of a straight edge or other tool to guide a cut mark across the board.

Accordingly, what is needed is a method and apparatus for reducing the time and improving the efficiency of installing building sheets such as backerboards, and more particularly, a building sheet that accomplishes some or all of these and other needs.

Summary of the Invention

Briefly stated, the preferred embodiments of the present invention describe building sheets with a plurality of grooves indented into a surface of the building sheet to provide a guide for cutting the building sheet along the grooves. Preferably, the grooves are arranged in a regularly repeating pattern and are spaced apart by a standard unit of measurement in order for a cutter to accurately size the building sheet to a precise dimension. A simple carbide-tip scoring knife, such as supplied by Superior Featherweight Tools Company, Industry, CA, is preferably used to score the sheet along the grooves, without the need for a straight edge, and the sheet is broken by simply bending the sheet along the score mark. The grooves are preferably provided at a depth into the surface of the sheet such that they do not substantially decrease the strength of the sheet or affect off-groove scoring and snapping. The design of the grooves is such that a score mark can be made between, across, or on a diagonal to the grooves and the material snaps so that the line of breakage follows the score mark and not the line of the nearby grooves.

Other indentations may also be provided into the surface of the building sheet. For instance, in one preferred embodiment, fastener indent areas may be provided at regularly spaced increments to receive nails or other fasteners. These indent areas allow the fastener to be inserted through the sheet with the head of the fastener being nailed or screwed flat or below the surface of the sheet. Edge markers may be indented along the edges of the sheet to further indicate desired measurement increments. Optionally, edges may be grooved, flat or set down. Set down areas at the edges of the sheet provide an area for nails, adhesives and joining tape to be placed onto the sheet without protruding above the surface of the sheet.

Thus, in one aspect of the present invention, a building sheet is provided. The sheet comprises a substantially flat board having a front surface and a back surface and a thickness defined there between. At least one surface groove is formed into one of the front surface and back surface. The groove defines a line of cutting adapted to guide a knifepoint across at least a portion of the board.

In another aspect of the present invention, the building sheet comprises a substantially flat board having a top edge, a bottom edge and opposing side edges, and opposing faces defined between the edges of the board. A surface grid system is provided on at least one of the opposing faces, the surface grid system including a plurality of cutting grooves indented into the face of the board that extend substantially across the face of the board in straight lines. The grooves are arranged in parallel and perpendicular to the edges of the board or to one another, and are capable of receiving a score mark for cutting and breaking the board.

In another aspect of the present invention, the building sheet comprises a substantially flat board having a front surface and a back surface and a top edge, bottom edge and opposing side edges. The board has a thickness defined between the front surface and back surface. At least one set down area is indented into one of said front surface and back surface. The at least one set down area is adapted to receive a fastener therein. In one embodiment, the at least one set down area includes a plurality of fastener guides arranged in a regularly repeating pattern across the surface of the board. In another embodiment, the at least one set down area includes an edge set down area adapted to receive a reinforcing tape therein.

In another aspect of the present invention, a building sheet construction is provided. This construction comprises a foundation layer having a front surface and a back surface, and a substantially flat board having a front surface and a back surface overlying the foundation layer. The back surface of the board overlies the front surface of the foundation layer. The front surface of the board has at least one pre-formed indentation into the surface thereof. At least one fastener having a head extends through the board into the foundation layer, wherein the fastener extends through an indentation such that the head of the fastener lies at or below the front surface of the foundation layer.

In another aspect of the present invention, a building sheet comprises a substantially flat board having opposing surfaces, and a plurality of indentations provided into at least one of said opposing surfaces. The board has a bending strength that has been reduced by no more than about 20%, more preferably about 10%, and even more preferably about 5% below than the bending strength of the same board without the plurality of indentations.

In another aspect of the present invention, a method of cutting a building sheet is provided. The building sheet is scored at a desired location on a surface of the sheet, the sheet having at least one cutting groove formed into the sheet. The scoring of the sheet forms a score mark in the surface. The sheet is bent along the score mark to break the sheet. In one embodiment, the sheet is scored such that the score mark lies within and substantially along a cutting groove. In another embodiment, the sheet is scored such that the score mark lies substantially outside of a cutting groove.

Brief Description of the Drawings

FIGURE 1 is a perspective view of a backerboard having a plurality of intersecting surface grooves.

FIGURE 2 is a top elevation view of a 3' x 5' backerboard having a plurality of intersecting surface grooves with a 1" spacing.

FIGURE 3 is a top elevation view of a 3' x 5' backerboard having a plurality of parallel surface grooves with a 1" spacing.

FIGURE 4 is a top elevation view of a 3' x 5' backerboard having a plurality of intersecting surface grooves with a 3" spacing.

FIGURES 5A-5F are cross-sectional views illustrating different groove configurations for a backerboard.

FIGURE 6 is a cross-sectional view of a 3" thick backerboard having differentiated V-shaped grooves.

FIGURE 7A is a perspective view of a backerboard having circular locators at the intersection of grooves at a 1 inch spacing.

FIGURE 7B is a top elevation view of a backerboard having circular locators at the intersection of grooves at a 1 inch spacing.

FIGURE 8A is a perspective view of a backerboard having diamond-shaped locators at the intersection of grooves at a 1 inch spacing.

FIGURE 8B is a top elevation view of a backerboard having diamond-shaped locators at the intersection of grooves at a 1 inch spacing.

FIGURES 9A is a perspective view of a backerboard having a plurality of parallel grooves indented therein being cut with a scoring knife along the groove.

FIGURE 9B is a cross-sectional view of the backerboard of FIGURE 9A being cut along a V-shaped groove.

FIGURE 9C is an enlarged cross-sectional view of the backerboard of FIGURE 9B being cut along a V-shaped groove.

FIGURE 10 is a perspective view of a backerboard having a plurality of grooves indented therein and a scoring knife cutting the board between the grooves.

FIGURE 11 is a top elevation view of a backerboard having a plurality of fastener indent areas.

FIGURE 12 is a top elevation view of a plurality of imprint or indent patterns that may be used as edge markers or fastener guides.

FIGURES 13A and 13B are cross-sectional views of a backerboard having fastener indent areas.

FIGURE 14 is a cross-sectional view of one embodiment of a pair of backerboards having a set down area fastened to a plywood flooring.

FIGURE 15A is a side view of one embodiment a backerboard having a set down area on both its front surface and its back surface.

FIGURE 15B is a side view of another embodiment of a backerboard having a set down area on its front face only.

Detailed Description of the Preferred Embodiments

Certain preferred embodiments of the present invention relate to a building sheet having a plurality of surface grooves provided therein that aid in cutting the sheet without the need for a straight edge. The building sheet is more preferably a backerboard for flooring or other surface treatments such as ceramic tile, countertops, walls and the like. However, it will be appreciated that the principles of the present invention may be applied to other types of building sheets, including, but not limited to, interior wallboard, wall panels, exterior sheathing, panel flooring, decking, ceiling panels, soffit panels, façade panels and general building and furniture flat panels.

FIGURE 1 illustrates one exemplary embodiment of a backerboard 10 having a plurality of surface grooves 12 provided thereon. The backerboard 10, before being sized and cut to its desired dimension for installation, is preferably a substantially flat, rectangular board having a top edge 14, a bottom edge 16, side edges 18 and 20, a front surface or face 22 and a back surface or face 24. The backerboard of the preferred embodiment is made of a fiber cement material, such as James Hardie Building Products' Hardibacker®, although other materials, such as plywood, hardboard,

oriented strand board (OSB), engineered wood, fiber-matte-reinforced cement substrate sheets, cement boards, gypsum based wallboards and cement-bonded particle boards may also be used.

In one embodiment, the fiber cement material is about 20% to 80% Portland cement, about 20% to 70% ground silica sand, about 0% to 12% cellulose fiber, and about 0% to 6% select additives such as mineral oxides, mineral hydroxides and water. Platelet or fibrous additives, such as, for example, wollastonite, mica, glass fiber or mineral fiber, may be added to improve the thermal stability of the fiber cement. The dry density fiber cement sheet is typically about 0.8 g/cm³ (low density) to about 1.3 g/cm³ (medium density) to about 1.8 g/cm³ or more (high density). Density can be modified by addition of density modifiers such as unexpanded or expanded vermiculite, perlite, clay, shale or low bulk density (about 0.06 to 0.7 g/cm³) calcium silicate hydrates. The moisture content of the fiber cement is preferably from about 1% to about 30%. The art of manufacturing cellulose fiber reinforced cement is described in the Australian patent AU 515151.

Typical backerboard sizes in accordance with the preferred embodiments of the present invention are 3' x 5', 4' x 4' and 4' x 8' having thicknesses of preferably 3" or greater. Other nominal thicknesses of 3/8, 7/16, ½ and 5/8 inch may also be used.

The grooves 12 illustrated in FIGURE 1 are preferably provided only on the front surface 22 of the backerboard 10, although it will be appreciated that grooves may be provided only on the back surface 24, or on both surfaces 22 and 24. Grooves may be desired for the back surface, for instance, when the front surface of the building sheet needs to be flat for painting or other applications. The grooves 12 illustrated in FIGURE 1 preferably include two sets of grooves, namely a first set 26 that runs parallel to the top and bottom edges 14 and 16, and a second set 28 that runs parallel to the side edges 18 and 20 and perpendicular to the first set 26. It will be appreciated that grooves may be provided at different angles on the backerboard, and may run in single or multiple directions.

The grooves 12 preferably run in straight lines across the face of the board. In one embodiment, the grooves stop short of the edges of the board, as shown in FIGURE 1. For example, a board that is 3' x 5' in size may have grooves that extend to about 1½ inches from the edges of the sheet. This distance is preferably short enough to allow a freehand cut from the end of the groove to the edge of the sheet. By stopping the grooves short of the edge of the sheet, these edge areas without groove indentations may be used for joining adjacent sheets with adhesive and tape, as described below. These edge areas also may be used for placement of increment identifiers as described below.

FIGURES 2 and 3 illustrate backerboards 10 that are preferably 3' x 5' in size having a plurality of grooves 12 indented therein. FIGURE 2 illustrates a board having both horizontal grooves 26 and vertical grooves 28 as in FIGURE 1, except that the grooves in FIGURE 2 extend all the way to the edges of the board. FIGURE 3 illustrates an embodiment in which only vertical grooves 28 are provided across the board.

The grooves 12 in the embodiments above are preferably arranged in a regularly repeating pattern, such that there is uniform spacing between the grooves of the first set 26, and there is uniform spacing between the grooves of the second set 28. As illustrated in FIGURE 2, when the groove spacing is preferably uniform, each groove of the first set 26 is set apart by a distance y, while each groove of the second set 28 is set apart by a distance x. More

preferably, the distance x is equal to the distance y. The distances x and y are preferably selected to correspond with a standard measuring unit to enable a quick determination as to the size of the board along each of the grooves. For instance, in the embodiment of FIGURE 2, the spacing x, y between the grooves is 1 inch. Similarly, for a board 10 as illustrated in FIGURE 3, a standard spacing between the vertical grooves 28 may also be 1 inch. It will be appreciated that the grooves may be placed closer or farther together as desired. Grooves placed closer together enable greater accuracy in cutting and reduces the time taken to measure, mark and cut the sheet. Thus, smaller increments as low as 1/32" of an inch or less and as large as 12" or more may also be used. For instance, FIGURE 4, described in further detail below, illustrates a 3' x 5' backerboard 10 having intersecting surface grooves with a 3" spacing.

The depth and shape of the grooves 12 are selected such that the grooves are capable of guiding a knifepoint, pencil or marker in a straight line along a groove. However, the depth of the grooves is preferably not so deep such that, when a diagonal score mark is made in the board surface across the groove lines, the board when bent breaks along a groove line instead of along the score mark. The depth of the grooves 12 is also preferably not so deep such that a diagonal score line across the groove lines causes a knifepoint to unintentionally track into the line of the groove. Moreover, the depth of the grooves is preferably not so deep such that the grooves substantially decrease the strength of the backerboard. For any particular board material and thickness, such a groove depth can be readily ascertained by simple empirical means, as described in more detail below.

Accordingly, in one embodiment the grooves 12 are preferably between about 0.001 inches and ½ the thickness of the sheet. More preferably, for a backerboard having a thickness of 3", the grooves 12 have a depth of about 0.01 to 0.06 inches. Even more preferably, the groove depth is preferably less than about 25% of the thickness of the board, more preferably less than about 15% of the thickness of the board.

The groove shape is capable of guiding a knife or marker such as a pencil, pen or texture. The cross-sectional shape of the grooves may be square, "V"-shaped, rectangular, semi-circular, oval, ellipse, or combinations thereof. FIGURES 5A-5F illustrate several embodiments for groove configurations, which can be V-shaped (FIGURES 5A and 5B), rectangular (FIGURE 5C), curved or semicircular (FIGURE 5D), trapezoidal (FIGURE 5E), or multisided (FIGURE 5F). Where a V-shaped cutting knife is to be used, V-shaped groove configurations may be preferable. It will be appreciated that groove configurations other than those described herein are also possible.

The shape of specific grooves on a backerboard may optionally be different to the general groove design to facilitate easy recognition of incremental dimensions. For example, such a differentiation would enable the recognition of 1 inch increments on a board such as shown in FIGURE 4 having a general ¼" increment groove spacing. FIGURE 6 illustrates an exemplary differentiation of the groove shape wherein approximately 0.0313" wide by 0.02" deep V-shaped grooves 26a are placed at ¼" increments and approximately 0.0625" wide by 0.02" deep V-shaped grooves 26b are placed at 1" increments. The wider grooves 26b at 1" increments make it easier to distinguish these grooves from the 3" grooves. It will be appreciated that other variations in groove shape, size and incremental spacing are also contemplated. In addition, the differentiation between the grooves can be accomplished by marking or printing in or by selected grooves, as well as through varying the size or shape of the grooves.

FIGURES 7A-7B illustrate another embodiment of a backerboard which enableseasy recognition of incremental grove spacing. As shown in FIGURES 7A and 7B, a backboard 10 is provided with evenly spaced parallel grooves 12 intersecting at right angles on the surface of the board. These grooves 12 are preferably V-shaped, and have the same size and shape throughout. In one embodiment, each of the grooves is spaced ¼" apart. To determine a desired spacing between grooves 12, locators 60 are preferably provided at the intersection of certain grooves, more preferably at regularly repeating increments across the board. For instance, in one embodiment, where the grooves are spaced at ¼" increments, the locators 60 are provided at 1 inch increments, and thus at every fourth grove both along the length and width of the board as shown in FIGURES 7A and 7B.

The locators 60 are preferably indented into the surface of the board of the intersection of the grooves. The shape of the locator 60 is preferably generally circular when viewed from above, as shown in FIGURE 7B, such that the boundaries of the locator extend outside the lines of the grooves to make the locator more recognizable. In one embodiment, the diameter of the locator 60 is about ¼" as compared to a groove width of about 0.04 inches. The surface of the locator is preferably sloped inward toward the intersection of the grooves to prevent a knife point from accidentally tracking into the locator during cutting. More preferably, the sloping of the surface of the locator makes the shape of the locator generally conical. The depth of the locator is preferably no more than the depth of the grooves, which in one embodiment, is about 0.02".

FIGURES 8A-8B illustrate a similar embodiment to that shown in FIGURES 7A-7B, except that the locators 60 have a diamond or square shape rather than a circular shape when viewed from above. The edges of the diamond preferably extend between the perpendicular intersecting grooves, and in the embodiment shown have a length of about 0.03 inches. The locators 60 shown in FIGURES 8A-8B more preferably have sloped surfaces defining a substantially pyramidal shape, with the apex of the pyramid corresponding to the point where the grooves intersect.

It will be appreciated that other shapes may be used to indicate the locators of intersecting grooves on the board. In addition to shapes and indentations, printed indicia can also be used to mark the locations of predetermined intersecting grooves. More generally, any type of locator may be used to mark the location of intersecting grooves at repeating increments across the board, where the increments are determined as a multiple of the standard groove spacing on the board.

FIGURES 9A-9C illustrate one preferred method for cutting a backerboard 10 having at least one groove indented therein. A board 10 having a plurality of parallel grooves 12 is provided. A cutting knife such as a utility knife, more preferably a carbide-tipped score and snap knife 30, cuts the board along one of the grooves. Optionally, a pencil or marker may be used to mark the board along the grooves prior to cutting to indicate the location that the cutting knife or other tool should follow. The groove 12 guides the knife 30 such that a score mark 32 is made across the board within the groove without the need for a straight edge. After scoring the board along the groove, the board is bent along the score mark 32 to break the board.

Cutting and breaking a board in this manner greatly reduces the time, labor and tools required for sizing and installation of the board. The surface groove pattern enables the location of the desired score mark to be easily

identified and the corresponding grooves enable a quick and easy score mark to be cut into the sheet so that the sheet can be snapped into the desired size. Thus, there is no need for a tape measure, line marking or straight edge. The only tool that is needed is a score knife that is light and easy to carry in a pocket or tool belt.

As discussed above, the depth of the grooves is preferably selected so as not to substantially decrease the strength of the backerboard. The reduction in strength of the board due to the presence of grooves can generally be determined, for example, by scoring the board at a location away from a groove, such as the flat region between grooves or across grooves, or diagonally across the line of the grooves. When bending the board to break it, the board should break along the scored mark and not along any of the grooves. Thus, FIGURE 10 illustrates cutting a board in an alternative manner, in which a board 10 has a plurality of grooves 28 and 28 as described above. However, the scoring knife 30 is used to make a score mark 32 between grooves 28 and across grooves 26. This score mark may be made with the assistance of a straight edge 34 as shown, or may also be made freehand or with another tool.

Because of the preferred specially selected depth of the grooves 26, scoring the board across grooves 28 does not cause the score mark to accidentally track into the grooves. This remains true even when the score mark is made at an angle other than 90° to the groove lines, because the depth of the score mark is preferably deeper than the depth of the grooves. For example, the depth of the score mark may be between about 0.8 mm and 1.2 mm. When this board 10 is bent in order to break it, the board will break along the score mark and not along any of the grooves 26 or 28. Thus, it will be appreciated that one particular advantage of the preferred embodiments of the present invention is that the grooved backerboard need not be cut along the grooves, and therefore the cut board is not limited in size or shape to the arrangement of the grooves. The grooves act as a guide only and is not a limitation of the cutting method.

Testing has been performed to demonstrate that formation of the grooves on the board does not decrease substantially the bending strength of the board. A flat, single fiber cement sheet having a thickness of 6.7 ± 0.2 mm was formed having regions with 0.02 inch deep grooves and regions without grooves. The sheets were cut into 250 mm x 250 mm test specimens and equilibrated at 50 ± 5% humidity and 73 ± 4 °F. The sheets were tested for bending strength using a three point bend test supported over a 165 mm span on a MTS mechanical testing machine. Ten specimens were tested, with the average results given below.

Table 1. Peak Loads of Grooved and Flat Backerboard

	Grooved Surface Strength (Newtons)	Flat Surface Strength (Newtons)
Face Up	687	700
Face Down	708	741

The results of this testing indicate that the strength of the board is not reduced by more than about 6% because of the grooves as compared to a flat surface backerboard. It will be appreciated that shallower or deeper groove depths will cause various reductions of the strength of a board. Thus, even boards that experience a greater reduction in the board's load carrying capacity, for example, up to about 10% and even up to about 20% because of the presence of

the grooves are still considered to be useful and within the scope of the invention. More generally, it will be appreciated that boards having grooves indented thereon remain useful so long as the diminished load carrying capacity of the board does not make it difficult to make diagonal or off-groove cuts, or where it becomes difficult to handle the board without the board breaking.

The various groove shapes and sizes are preferably formed by processes such as machining, molding and embossing. Machining includes all wood and metal machining tools such as planers, routers, double end tendon machines, drills, lathes, spindle molders, circular saws, milling machines, etc. Molding the shapes in the material surface can be done during formation of an article in a flat casting mold or on an accumulation roller. Also casting, extrusion, injection-molding processes can also be used. Embossing the shapes in the material surface can be done after the material has been formed but preferably when the article is in a green state (plastic state prior to hardening). The embossing can be done by a patterned roller or plate being pressed into the surface or the sheet. Laser etching may also be used to form the grooves in the sheet.

More preferably, a patterned accumulator roll of a Hatschek process and a roll embossing process have been used to form the grooves in fiber cement board. In the embossing process, approximately 2,000 to 4,000 pounds per linear foot are required to emboss the grooves onto the green article.

It is an advantage of the accumulator roll formation process that a diagonal score and snap cut at an angle to the grooves is not hindered by the break line unintentionally tracking off to the line of the grooves. This is because the laminate formation of the material is not broken unlike a material post-cure machined groove. More particularly, the accumulator roll process compresses the laminate formation in the grooved region, thereby increasing the localized density around the groove, whereas a machining or cutting process to form the grooves tends to create defects which can lead to crack propagation and even breakage during handling. Thus, a board having grooves formed by the accumulator roll process exhibits greater bending strength than a similar board with grooves formed by machining.

Optionally, the backerboard embodiments illustrated in FIGURES 1-4 above also include guide patterns 40 which are used to indicate locations where fasteners such as nails can be placed to fasten the backerboard to underlying materials such as plywood. These guide patterns may be optionally formed or imprinted onto the face of the sheet as a guide for nail fastening, or may be indented below the surface of the board. Nail patterns, for instance, may be provided in boards having grooves, such as shown in FIGURES 1-4, or without grooves, as shown in FIGURE 11. When provided on a board having grooves, such as in FIGURES 1-4, the nail patterns 40 preferably intersect the grooves and are spaced apart by a unit measurement (for instance, 6" in FIGURES 2-4). It will be appreciated that nail patterns 40 can also be provided with other spacing, and also between grooves on the backerboard.

In one preferred embodiment, the nail patterns 40 are indentations in the surface of the board to form nail guide indents. For a ¼" board, the depth of the nail guide indents is preferably between about 0.005 inches and ¼ the sheet thickness. More preferably, when the nail guide indents intersect with the grooves on the board, the depth of the indents is at least as deep as the grooves so as not to interfere with the scoring of the board through the grooves. In one embodiment, where the grooves are 0.02" deep, the nail guide indents are 0.04" deep.

FIGURES 1-4 and 11 illustrate the nail guide pattern as being a circle. The diameter of the circle is preferably large enough to at least accommodate the head of the fastener to be inserted therein. As shown in the embodiment of FIGURE 4, this circle preferably has a diameter of 0.25 to 1 inch, more preferably about 0.45". It will be appreciated that, whether the pattern is an imprint or is indented into the surface of the board, the pattern may have other shapes, such as a round or oval dot, a short line, a broken line, an intersection set of short lines, a circle, a semicircle, a triangle, a square, a rectangle, or a polygon. A variety of possible patterns are shown in FIGURE 12, described in further detail below.

When the nail guide pattern is an indentation formed into the surface of the material, the shape and size of the indentation shall be preferably sufficient to accommodate the head of the nail below the main surface of the material. FIGURE 13A illustrates one embodiment of a ¼" backerboard 10 fastened to a plywood flooring 36 using an adhesive, such as portland cement mortar thinset 38. A fastener or nail indent area 40 is provided on the top surface 22 of the backerboard for receiving fastener or nail 42, which is preferably a 1 ¼" corrosion resistant roofing nail. The nail indent area 40 is an indentation defining a set down area extending below the top surface 22 such that the head of the nail 42, when driven through the backerboard into the plywood, does not extend above the top surface 22. In the embodiment shown in FIGURE 13A, the bottom surface 24 of the backerboard 10 also has a close to corresponding set down area 44 below the nail indent area 40 when formed using a Hatschek or similar process. Alternatively, the bottom surface 24 may be completely flat, as in FIGURE 11B, such as when the indentation is formed by a machining or an embossing process.

The nail guides 40 illustrated in FIGURES 1-4 and 11 provide locations for nails in a regularly spaced arrangement around the board 10. However, near the edges of the board, the nail guides 40 are preferably placed slightly inward of the edge to accommodate fastening near the edges. As illustrated in FIGURE 2, for nail guides 40 generally spaced 6" apart in a 3' x 5' board, near the edges of the board the nail guides 40 are preferably placed 2" from the edges. More particularly, near the corners of the board the guides 40 are placed 2" from one edge and 2" from the other. It will be appreciated that these dimensions are purely exemplary, and therefore, other nail guide spacing may also be used.

FIGURE 14 illustrates another optional embodiment in which the edges of the board have a set down area to accommodate nails, adhesive and alkali resistant fiberglass reinforcing tape found at the joint of two boards. When laying two backerboards adjacent each other, adhesive tape is often used to tape the joint along the edges of the adjacent backerboard. FIGURE 14 illustrates such a joint 48 between two adjacent backerboards 10a and 10b fastened to plywood flooring 36 through adhesive 38. Near the edges 20 and 18 of backerboards 10a and 10b, respectively, nails 42 are driven through the backerboards to fasten the boards to the plywood 36. Reinforcing tape, such as an alkali resistant fiberglass backer tape 50, is placed over the head of the nails to join the boards together.

The backerboards 10a and 10b each preferably has an edge set down area 46 on the front surface 22 thereof at the edge near the joint 48, where the front face 22 of the boards is recessed or set down by a distance t, illustrated in FIGURES 15A and 15B. This set down area 46 provides a location for setting the backerboard, using

nails 42 as described above driven through the board into the plywood 38. Because of the set down area, the heads of the nails do not extend above the surface 22. In addition, the reinforcing tape 50 provided over the joint and over the nails 48 is completely within the set down area 48 and does not rise above surface 22. As shown in FIGURE 14, the set down area 42 is preferably filled with portland cement mortar thinset 52 or other adhesive to provide a flat surface for the adhesion of tile or other building products. The set down thus has the advantage of providing a space for joint setting compounds, fasteners and reinforcing fabrics to fill to a level flat with the surface of the main sheet while enabling the strengthening of the connection between two sheets.

In the embodiment of FIGURES 14-15B, the plywood flooring 36 preferably has a thickness of about ¾", and the backerboards 10a and 10b each has a thickness of about ¼". The nails 42 are preferably about 1¼" in length, and the backer tape 50 is about 2" wide. The width s of the set down from the edge of the sheet shall be sufficient to accommodate reinforcing tape in the joint between two sheets are placed alongside each other. When the reinforcing tape is about 2 inches wide, the set down width is preferably greater than half this width, about 1 inch. Preferably, the widths of the edge set down is about 1.25 inches to allow for clearances. The width may be designed in other ways to suit the reinforcing tape width.

The depth t of the set down is preferably sufficient to accommodate a flat head fastener, such as a roofing nail or a bugle-head screw, plus reinforcing tape and joint setting compounds such that the joint can be set flat with the main flat surface of the sheet. Preferably, a set down t of about 0.04 inches is used, and more preferably is not less than about 0.005 inches and not greater than about ½ the thickness of a ¼" sheet. An advantage of this design is that nail or screw heads are accommodated by lower regions to ensure that the surface flatness is not interrupted by high points that may act as stress concentrators when loaded in application. The set down area also helps ensure that the nail is not overdriven into the material such that the nail's sheet pull through strength is reduced.

The embodiment illustrated in FIGURE 14 depicts the backerboards 10a and 10b as having a bottom surface also having a set down depth. Alternatively, a board with this type of construction is also shown in FIGURE 15A. FIGURE 15B illustrates a similar board wherein the bottom surface 24 is completely flat.

It will be appreciated that in boards having an edge set down area, the grooves may or may not extend into this area because of the recessed depth of the area. The edge set down area may also be used for edge markers, as described below.

The nail guide indentations and other set downs may be formed into the boards by many processes such as forming the set down during formation of the sheet, using an accumulator roll, embossing the set down into the green-sheet or machining the set down out of the surface of the building sheet. These and other methods have been described above with respect to forming the grooves.

In another embodiment, accurate sizing of the board may further be assisted by providing edge markers on the surface of the board adjacent the grooves. These edge markers are preferably formed into the face of the sheet near the edges to indicate incremental distances or measurements. Furthermore, where the board has edge set down areas as described above, these edge markers may be provided in the set down areas. FIGURE 12 illustrates several

embodiments for marker shapes. As illustrated, the edge marker pattern can be an imprint or formed groove or indent in the shape of a round or oval dot, a short line, broken line, intersection set of short lines, circle, semicircle, triangle, square, rectangle, polygon, combinations thereof, or other shapes, characters or indicia. Edge markers may also be indented numbers to indicate certain increments.

Edge markers preferably designate a particular increment of distance, usually a multiple of the smallest increment, the smallest increment preferably being the distance between adjacent grooves. The marker is preferably formed to have the full shape formed into the surface of the board such that the surface of the marker shape is slightly lower than the surrounding sheet surface. Grooves as described above may extend all the way across the sheet to the edges through the markers, or may stop short of the edge markers.

In a preferred embodiment, FIGURE 4 illustrates a backerboard 10 having edge markers indented into the top surface 22. Edge markers 54a and 54b as shown are provided at generally 6" increments for the 3' x 5' backboard, although it will be appreciated that other increments, such as 1 inch or 12 inches, may also be used. The markers are preferably straight lines extending inward from the edges of the board. The markers are preferably indented below surface 22, more preferably 0.04" deep for a ¼" board. FIGURE 4 also illustrates that different edge markers may be used around the board. Thus, as illustrated, longer line markers 54a are provided at a 1' spacing around the board, while shorter line markers 54b are provided between the markers 54a at a 6" spacing. Near the corners of the boards markers 54c are provided to designate the minimum distance to the corners for nailing, which is typically about 2 inches. It will be appreciated that this marker shape and arrangement is purely exemplary, and thus other markers in different arrangements may be used to indicate measurement units on the board.

One particular advantage of the indentations described above, including the grooves, locators, nail indents, edge marker indents, set down areas, etc. is that these indentations provide a mechanical keying effect and increased surface area for bonding with an overlying material, such as ceramic tile. The indentations are thus capable of receiving adhesive therein. The greater contact area of the adhesive and the grooves' and other indentations' shape in the surface provides increased thinset/backer connection strength against tensile and shear forces.

Moreover, because in several embodiments the building sheet is used as an underlay layer, the grooves do not affect the utility of the material. This is significant because for many applications, grooves cannot be made in the face because the face must remain flat to obtain a smooth finished surface for painting typical of most interior wall finishes and/or other reasons. In one embodiment, the backerboards described herein need not have flat faces because these faces are used to adhere other materials. Moreover, even when a building sheet with a completely flat surface is desired, the principles taught herein may be used to indent grooves and/or other indentations on the other side of the sheet.

Generally, the above-described embodiments provide for quick and easy installation of a building sheet material by providing incremental visual reference for measuring the desired sheet-cutting pattern, then marking and cutting out the building sheet using an indented pattern or score guide in the surface of the sheet as a guide. The score guide makes the installation quicker and easier because fewer if any measured markings need to be made on the

sheet. An indent pattern in the face of a sheet can be used as a guide for a score knife without requiring a straight edge to guide the cut or as a guide for a pencil or marker to mark the layout of the cut without requiring a straight edge to mark the cut layout. An indent pattern may also be provided to indicate appropriate nailing locations and desired cutting locations. The process involves forming an indented pattern into the surface of the material that provides a guide for cutting the sheets to size for installation. The pattern may be formed off a molded pattern or pressed or embossed or laser cut or machined into the surface of fiber cement sheet to produce a pattern of small straight grooves that provide a guide for measurement and cutting when installing sheet building material. Application of this invention is particularly advantageous to, but not limited to, the installation of cement-based building sheets, such as cement-based tile backer board.

General practice during installation of backerboard requires cutting sheets to fit over a floor or other area in a brick pattern layout. The cut-outs in a sheet are most commonly parallel or perpendicular to the sheet edges of the sheet. The pattern of grooves in the face of the sheet are parallel and perpendicular with the sheet edges. Considerable time and effort is therefore saved in not having to mark out two measurements for parallel nor require a straight edge to join the marks to form a line of cut. Furthermore, a straight edge or Plasterer's "T"-square device of sufficient stiffness to guide the knife is not required because the grooves guide the tip of the knife. Since no straight edge tool is require to guide or mark most of the cuts, fewer tools are needed to be located or moved around as part of the installation procedure, therefore speeding up the installation time and improving the ease of installation.

The embodiments illustrated and described above are provided merely as examples of certain preferred embodiments of the present invention. Various changes and modifications can be made from the embodiments presented herein by those skilled in the art without departure from the spirit and scope of the invention, as defined by the appended claims.

WHAT IS CLAIMED IS:

1. A building sheet, comprising:

a substantially flat board having a front surface and a back surface and a thickness defined therebetween; and

at least one surface groove formed into one of said front surface and back surface, said groove defining a line of cutting adapted to guide a knifepoint, pencil or marker across at least a portion of the board.

2. The building sheet of Claim 1, further comprising at least one guide pattern for placement of a fastener.

3. The building sheet of Claim 2, wherein the at least one guide pattern is indented into one of said front surface and back surface.

4. The building sheet of Claim 1, wherein the board has a thickness of about ¼ of an inch.

5. The building sheet of Claim 1, wherein the at least one surface groove has a depth of between about 0.001 inches and ½ the thickness of the board.

6. The building sheet of Claim 4, wherein the at least one surface groove has a depth of between about 0.02 and 0.06 inches.

7. The building sheet of Claim 1, wherein the at least one groove is formed in a straight line across the board.

8. The building sheet of Claim 1, wherein the at least one groove comprises a first plurality of parallel grooves.

9. The building sheet of Claim 8, wherein each of the plurality of parallel grooves is set apart by a standard measurement unit.

10. The building sheet of Claim 9, wherein the standard measurement unit is between 1/32" and 12".

11. The building sheet of Claim 9, wherein the standard measurement unit is 3".

12. The building sheet of Claim 9, wherein the standard measurement unit is 1 inch.

13. The building sheet of Claim 8, further comprising a second plurality of parallel grooves arranged at an angle to the first plurality of parallel grooves.

14. The building sheet of Claim 13, wherein the angle is a right angle.

15. The building sheet of Claim 1, wherein the at least one surface groove has a shape selected from the groove consisting of V-shaped, rectangular, curved, trapezoidal and multisided.

16. The building sheet of Claim 1, wherein the at least one surface groove includes at least one groove having a first visual appearance and at least one groove having a second visual appearance.

17. The building sheet of Claim 16, wherein the at least one groove having a first visual appearance includes a plurality of parallel grooves extending at least partially across the board, having a first shape, and the at

least one groove having a second visual appearance includes a plurality of parallel grooves extending at least partially across the board, having a second shape.

18. The building sheet of Claim 17, wherein the plurality of parallel grooves having a first shape and the plurality of parallel grooves having a second shape are parallel to one another.

19. The building sheet of Claim 18, wherein the plurality of parallel grooves having a first shape are set apart by a standard measurement unit.

20. The building sheet of Claim 19, wherein the plurality of parallel grooves having a second shape are arranged between the plurality of parallel grooves having a first shape and are set apart by a standard measurement unit.

21. The building sheet of Claim 20, wherein the plurality of parallel grooves having a first shape are set apart by 1", and the plurality of parallel grooves having a second shape are set apart by 3".

22. The building sheet of Claim 16, wherein the at least one groove having a first visual appearance and the at least one groove having a second visual appearance are both V-shaped.

23. The building sheet of Claim 22, wherein the at least one groove having a first visual appearance is wider than the at least one groove having a second visual appearance.

24. A building sheet, comprising:

a substantially flat board having a top edge, a bottom edge and opposing side edges, and opposing faces defined between the edges of the board; and

a surface grid system on at least one of the opposing faces, the surface grid system including a plurality of cutting grooves indented into the face of the board that extend substantially across the face of the board in straight lines, wherein the grooves are capable of receiving a score mark for cutting and breaking the board.

25. The building sheet of Claim 24, wherein the grooves are arranged parallel and perpendicular to the edges of the board.

26. The building sheet of Claim 24, wherein the grooves are arranged parallel and perpendicular to one another.

27. The building sheet of Claim 26, further comprising a plurality of locators provided at intersections of the parallel and perpendicular grooves, and wherein the grooves are equally spaced apart.

28. The building sheet of Claim 27, wherein the plurality of locators are provided at regularly repeating increments across the board, the increment being a multiple of the spacing of the grooves.

29. The building sheet of Claim 28, wherein the grooves are spaced ¼" apart.

30. The building sheet of Claim 29, wherein the locators are spaced 1 inch apart.

31. The building sheet of Claim 27, wherein the locator is circular.

32. The building sheet of Claim 27, wherein the locator is diamond shaped.

33. The building sheet of Claim 24, wherein the grooves extend substantially to the edges of the board.

34. The building sheet of Claim 24, wherein the grooves stop short of at least one edge of the board.

35. The building sheet of Claim 24, wherein the board having surface grooves indented into the face thereof has a strength that is not less than about 85% of the strength of a board having the same size and dimension but without the grooves.

36. The building sheet of Claim 24, wherein the grooves are indented into the board to a depth such that a knifepoint cutting across a groove at an angle to the groove does not substantially track into the groove, and such that a knifepoint scoring the board between grooves to form a score mark causes breakage of the board substantially along the score mark and not along any of the grooves.

37. The building sheet of Claim 24, wherein the board is backerboard.

38. The building sheet of Claim 37, wherein the backerboard is made of fiber cement.

39. The building sheet of Claim 24, further comprising edge markers provided on the face of the board adjacent the surface grid system to indicate incremental distances between grooves.

40. The building sheet of Claim 39, wherein the edge markers are indented into the surface of the board.

41. The building sheet of Claim 24, further comprising a plurality of fastener guides provided on the face of the board containing the surface grid system.

42. The building sheet of Claim 41, wherein the fastener guides are set apart by a standard measurement unit.

43. The building sheet of Claim 42, wherein the fastener guides intersect at least one groove of the surface grid system.

44. The building sheet of Claim 41, wherein the fastener guides are indented into the surface of the board.

45. The building sheet of Claim 44, wherein the fastener guides are indented to a depth that is greater than the depth of the grooves.

46. The building sheet of Claim 44, wherein the fastener guides are indented to a depth that is larger than the head of nail to be inserted in the fastener guide.

47. The building sheet of Claim 24, wherein the substantially flat board has a set down area at at least one of the edges, wherein the surface of the set down area is below the surface of the face.

48. A building sheet, comprising:

a substantially flat board having a front surface and a back surface and a top edge, bottom edge and opposing side edges, the board having a thickness defined between the front surface and back surface; and

at least one pre-formed set down area indented into one of said front surface and back surface, the at least one set down area adapted to receive a fastener therein.

49. The building sheet of Claim 48, wherein the at least one set down area has a depth between about 0.005 inches and ½ the board thickness.

50. The building sheet of Claim 48, wherein the at least one set down area has a depth of about 0.04".

51. The building sheet of Claim 48, wherein the at least one set down area comprises a plurality of fastener guides arranged in a regularly repeating pattern across the surface of the board.

52. The building sheet of Claim 51, wherein each of the plurality of fastener guides is formed in the shape of a circle.

53. The building sheet of Claim 48, wherein the at least one set down area comprises an edge set down area.

54. The building sheet of Claim 53, wherein the edge set down area is sized to receive a reinforcing tape therein.

55. A building sheet construction, comprising:

a foundation layer having a front surface and a back surface;

a substantially flat board having a front surface and a back surface overlying said foundation layer, the back surface of the board overlying the front surface of the foundation layer, the front surface of the board having at least one indentation into the surface thereof; and

at least one fastener having a head extending through the board into the foundation layer, wherein the fastener extends through an indentation such that the head of the fastener lies at or below the front surface of the board.

56. The building sheet construction of Claim 55, wherein the foundation layer is plywood.

57. The building sheet construction of Claim 55, further comprising an adhesive joining the front surface of the foundation layer with the back surface of the board.

58. The building sheet construction of Claim 55, wherein the at least one indentation extends to an edge of the board.

59. The building sheet construction of Claim 58, further comprising a tape extending over the head of the at least one fastener.

60. The building sheet construction of Claim 55, wherein the at least one indentation includes a plurality of indentations arranged in a regularly repeating pattern across the surface of the board.

61. A building sheet, comprising:

a substantially flat board having opposing surfaces; and

a plurality of indentations provided into at least one of said opposing surfaces;

wherein the board has a bending strength of at least about 80% of the bending strength of the same board without the plurality of indentations.

62. The building sheet of Claim 61, wherein the board has a bending strength of at least about 90% of the bending strength of the same board without the plurality of indentations.

63. The building sheet of Claim 61, wherein the board has a bending strength of at least about 95% of the bending strength of the same board without the plurality of indentations.

64. The building sheet of Claim 61, wherein at least some of the plurality of indentations is adapted to receive an adhesive.

65. The building sheet of Claim 61, wherein said plurality of indentations includes surface cutting grooves.

66. The building sheet of Claim 61, wherein said plurality of indentations includes fastener indent areas.

67. The building sheet of Claim 61, wherein said plurality of indentations includes edge markers.

68. The building sheet of Claim 61, wherein said plurality of indentations includes edge set down areas.

69. A method of cutting a building sheet, comprising:

scoring the building sheet at a desired location on a surface of the sheet, the sheet having at least one guide groove formed into the sheet, the scoring of the sheet forming a score mark in the surface; and

bending the sheet along the score mark to break the sheet.

70. The method of Claim 69, wherein the sheet is scored using a knifepoint.

71. The method of Claim 69, wherein the sheet is scored such that the score mark lies within and substantially along a guide groove.

72. The method of Claim 69, wherein the sheet is scored such that the score mark lies substantially outside of a guide groove.

73. The method of Claim 72, wherein the score mark cuts across at least one guide groove.

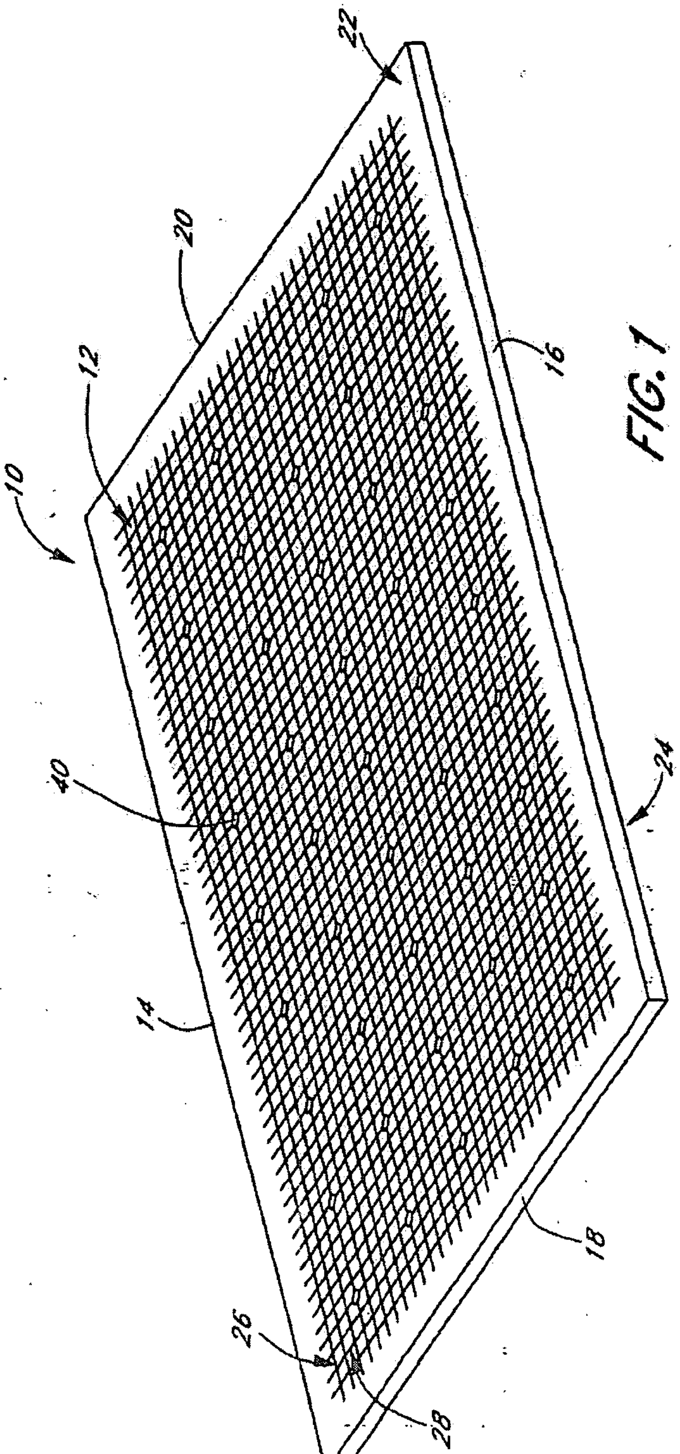

FIG. 1

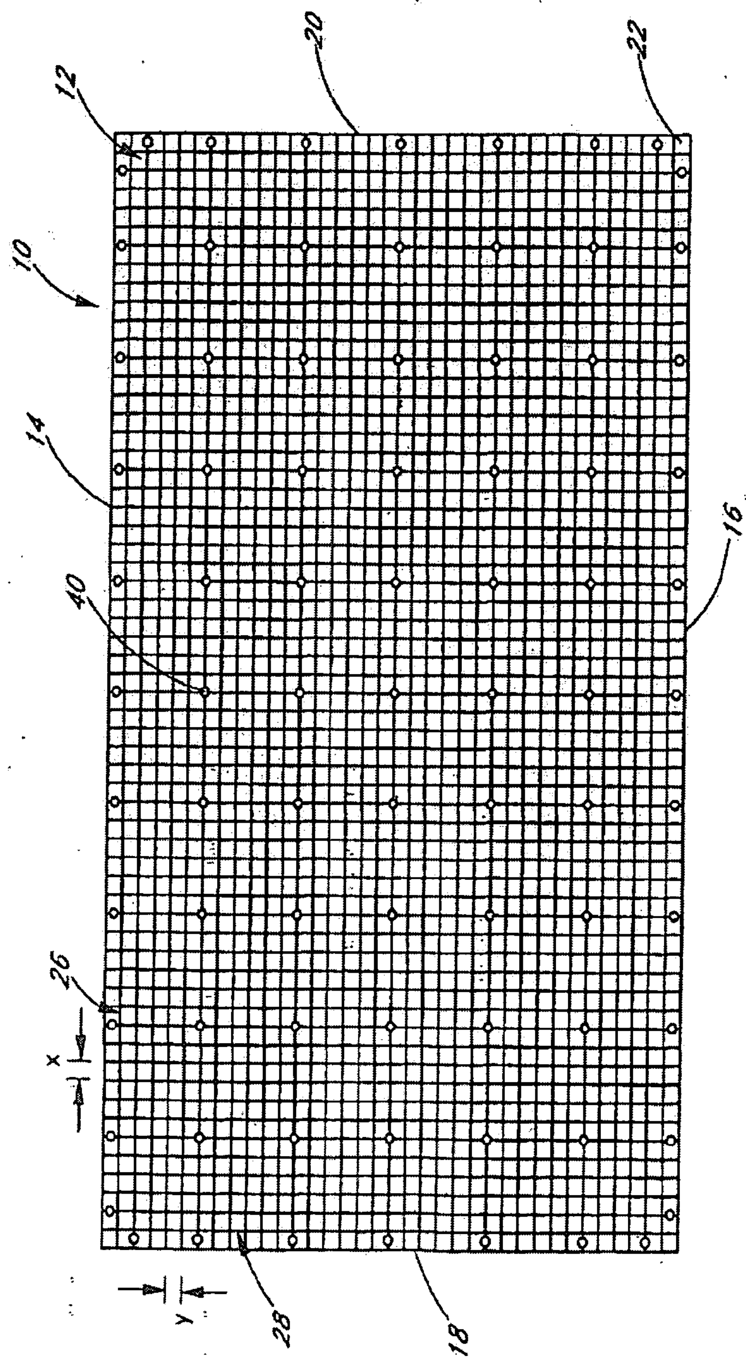

FIG.2

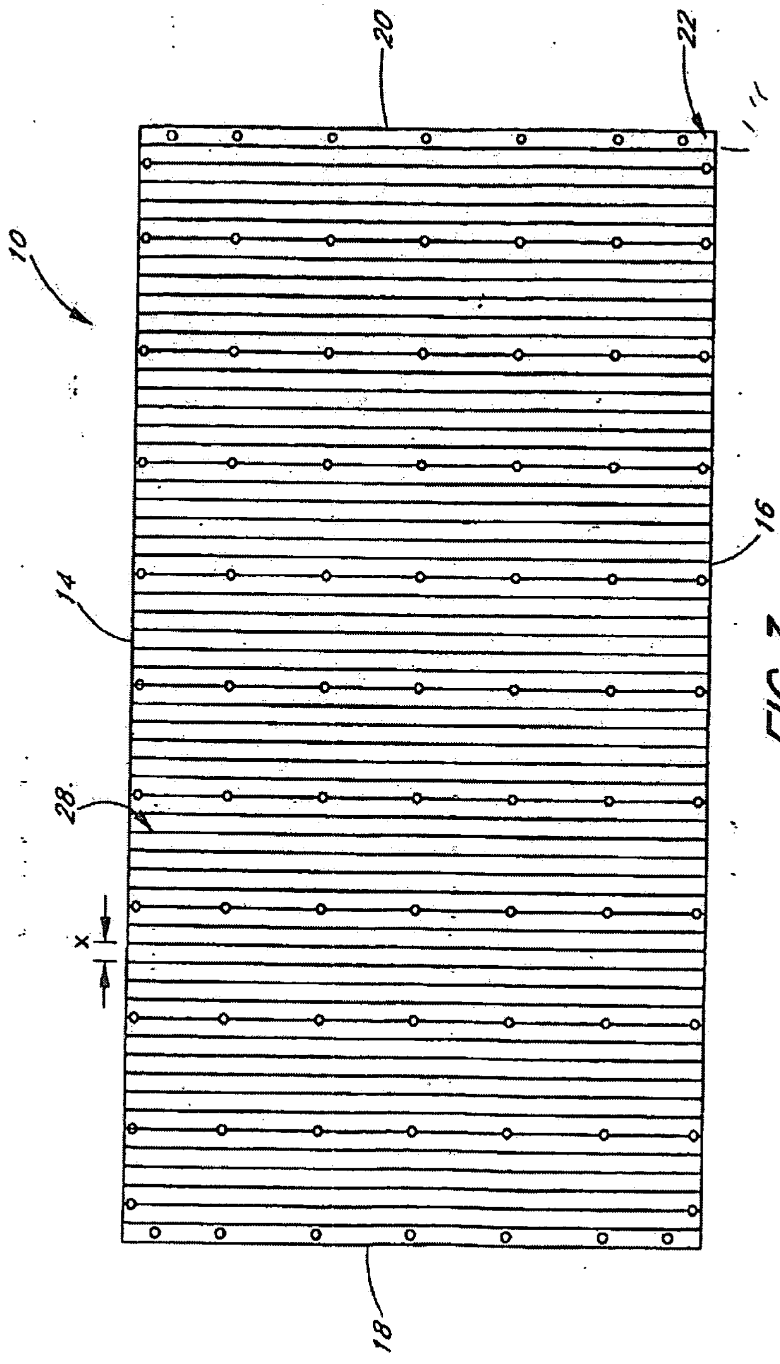

FIG. 3

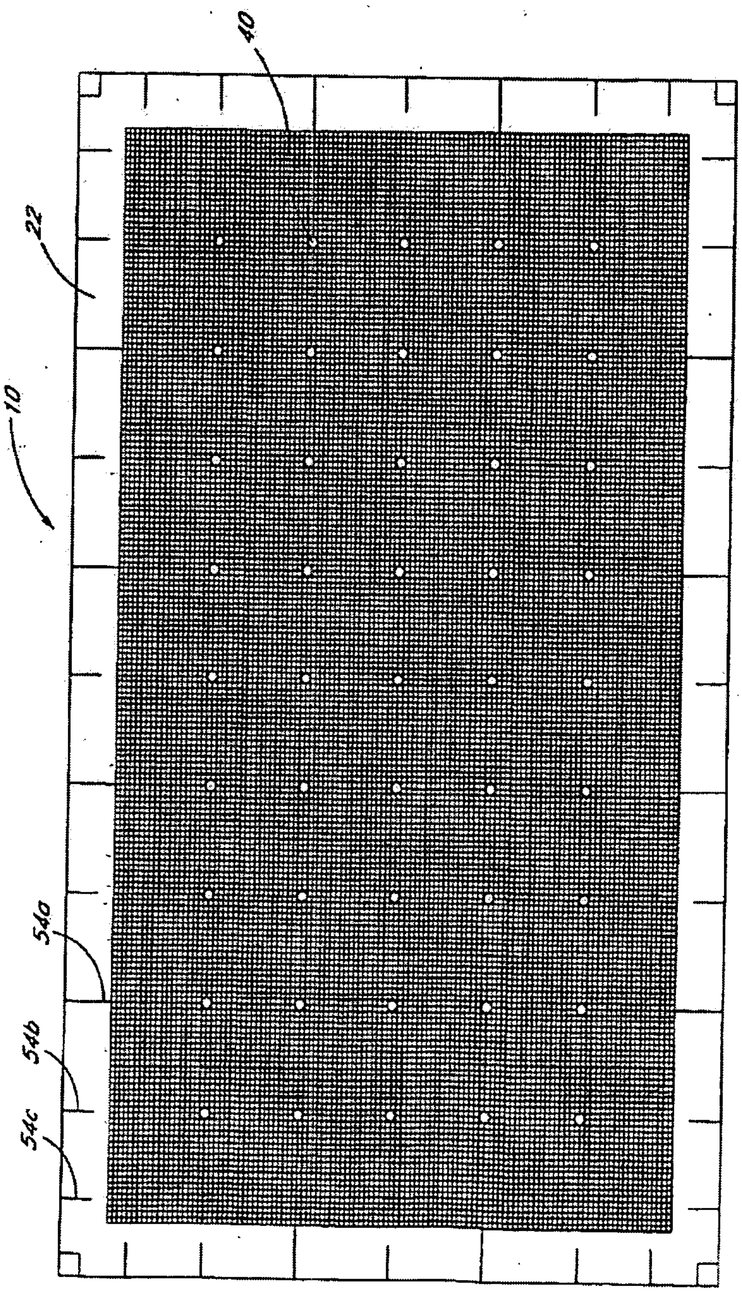

FIG. 4

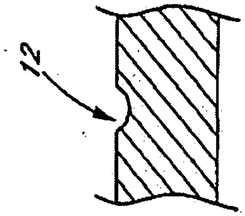

FIG.5F

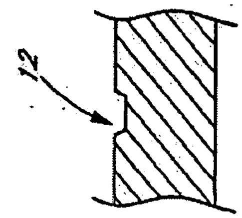

FIG.5E

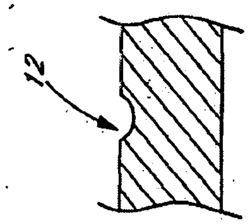

FIG.5D

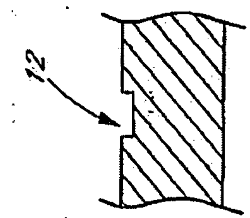

FIG.5C

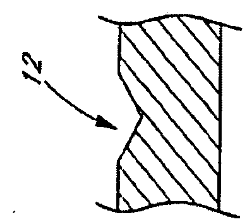

FIG.5B

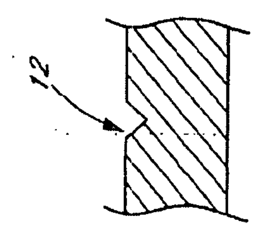

FIG.5A

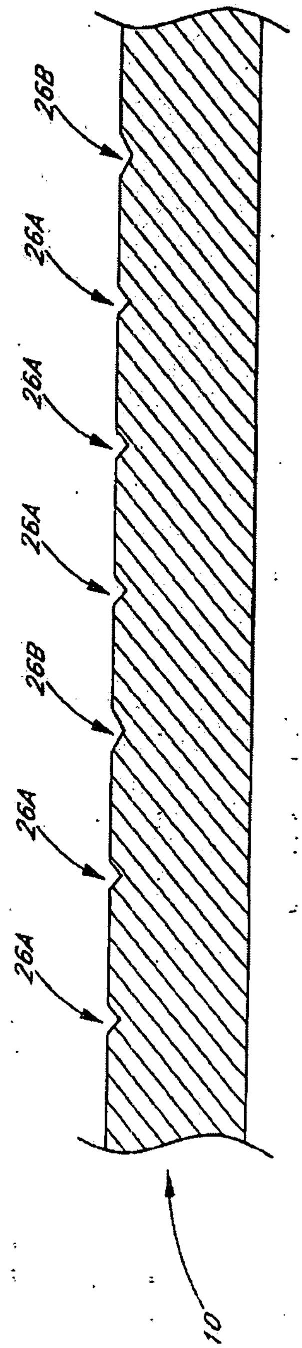

FIG. 6

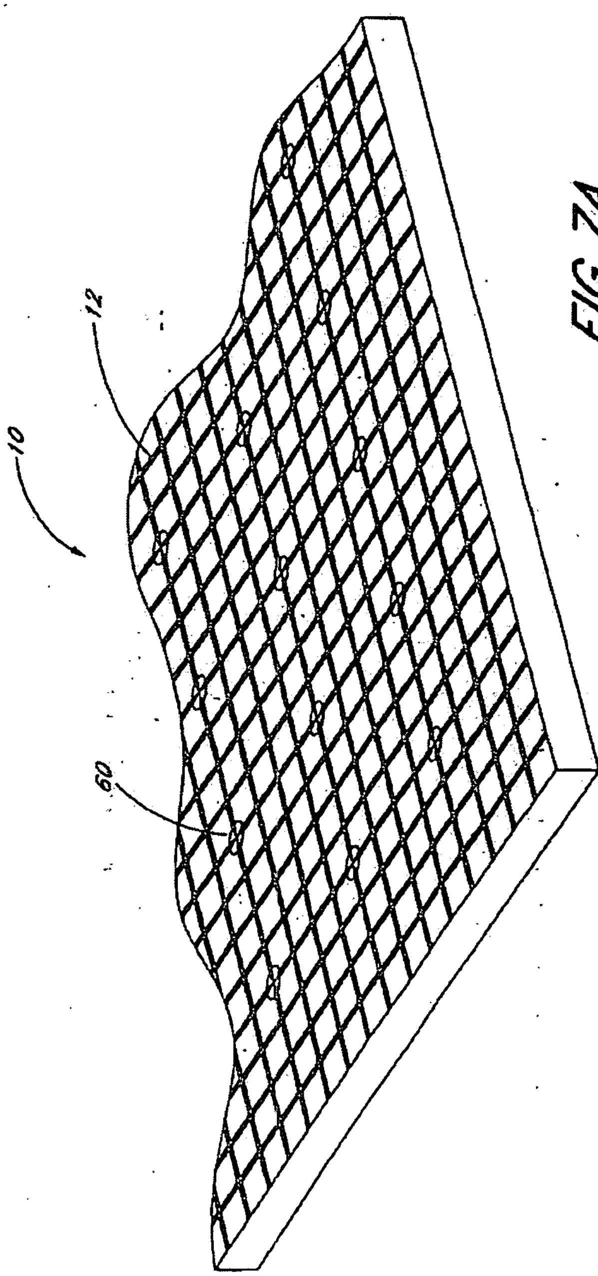

FIG. 7A

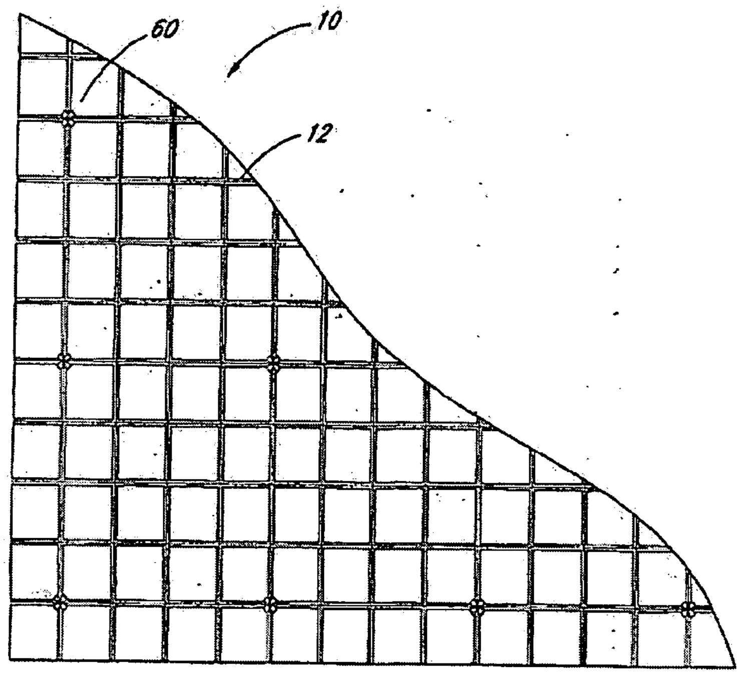

FIG. 7B

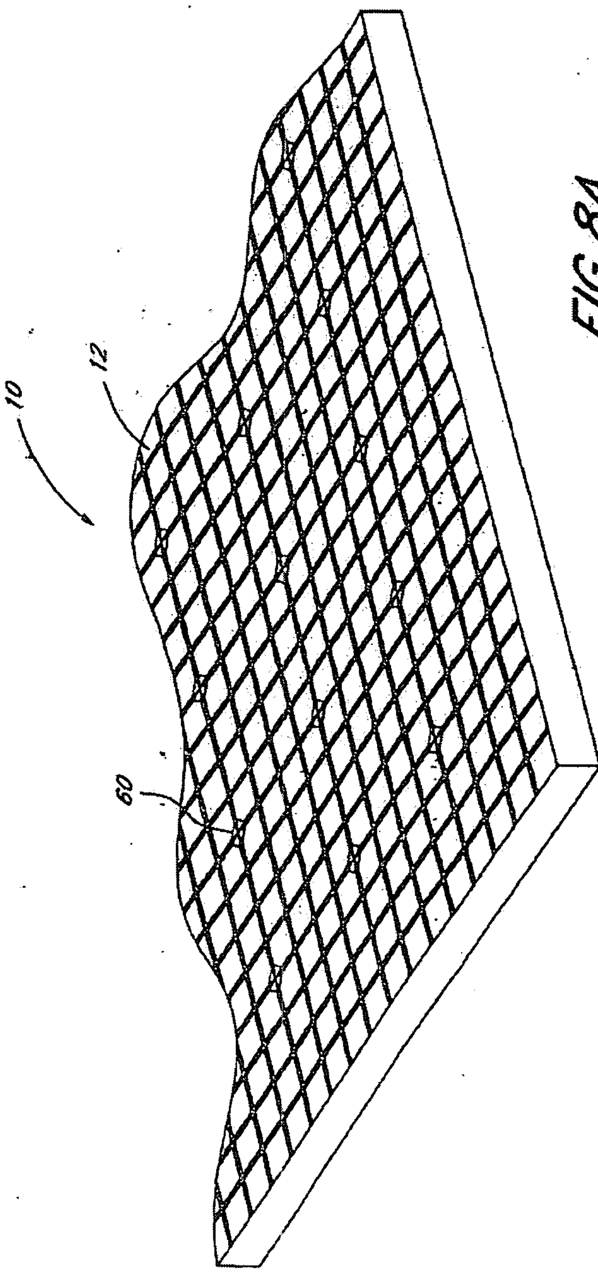

FIG. 8A

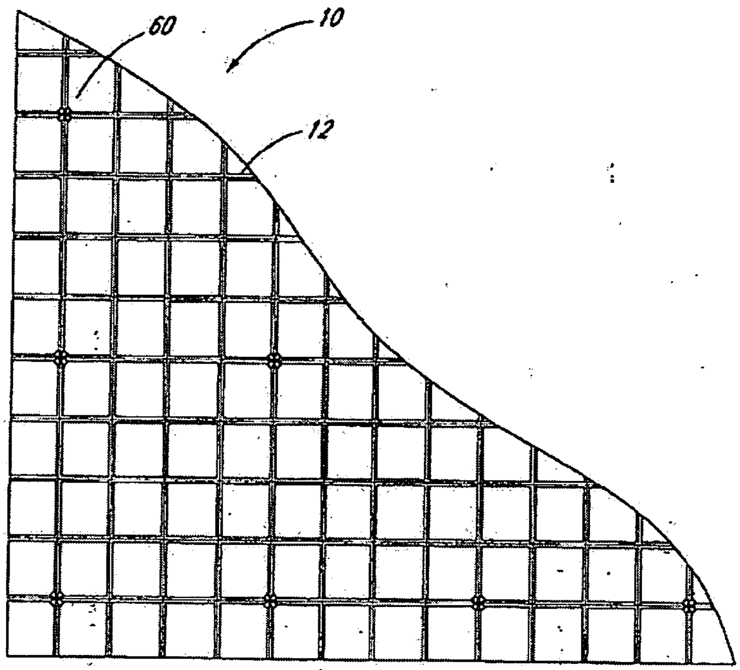

FIG.8B

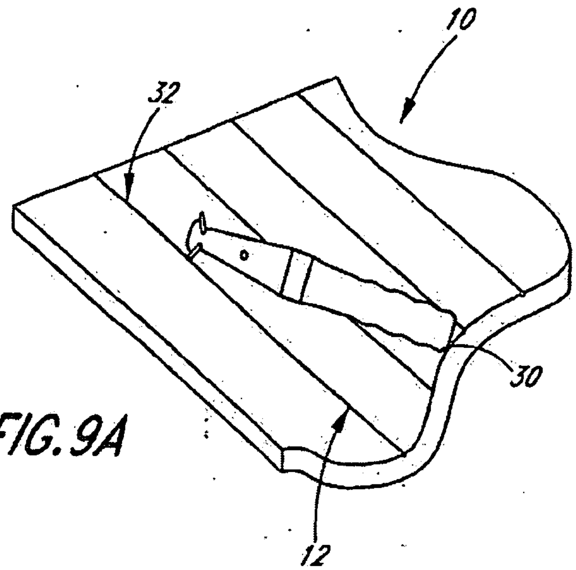

FIG. 9A

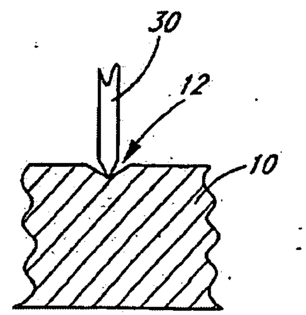

FIG. 9C

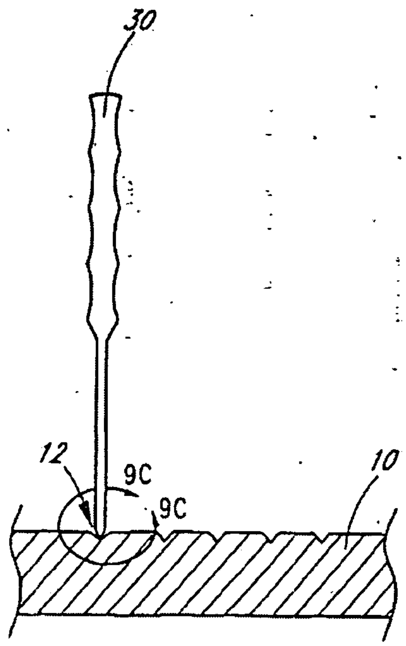

FIG. 9B

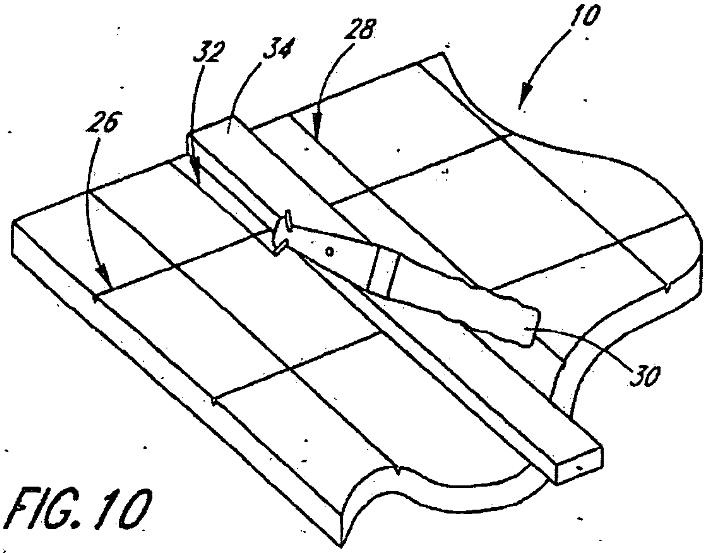

FIG. 10

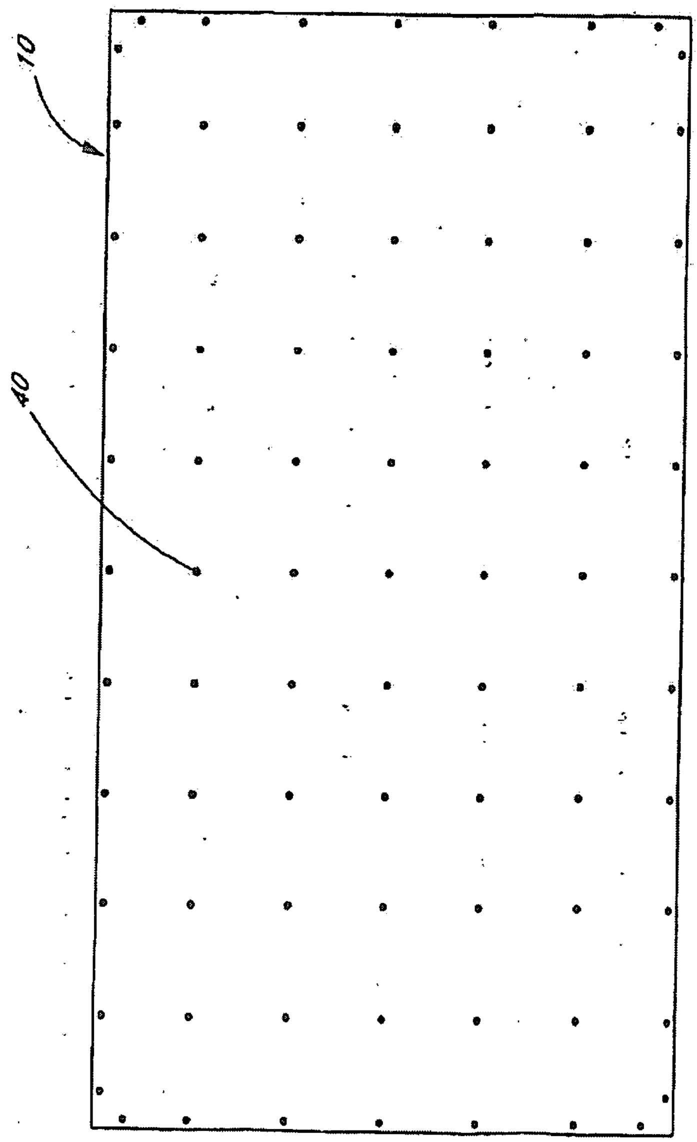

FIG. 11

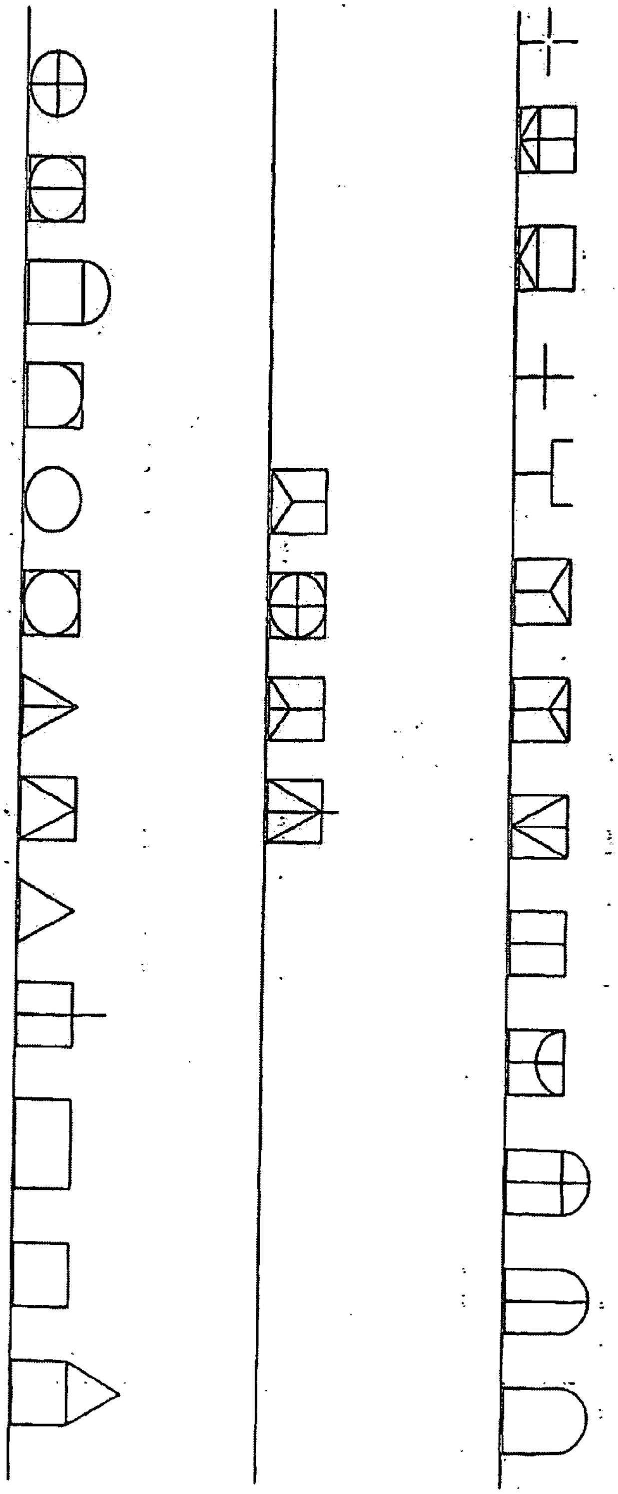

FIG. 12

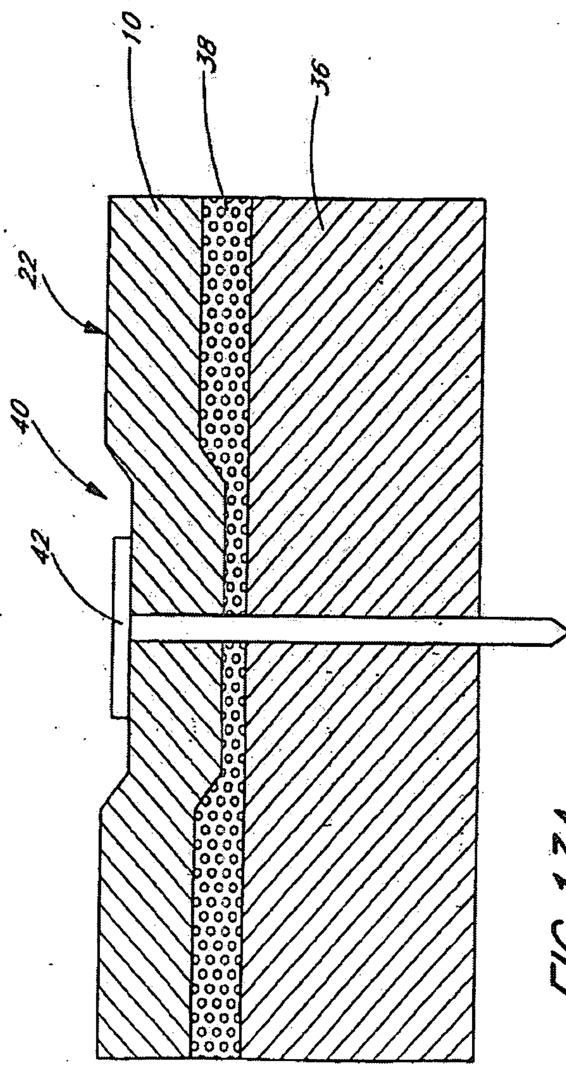

FIG. 13A

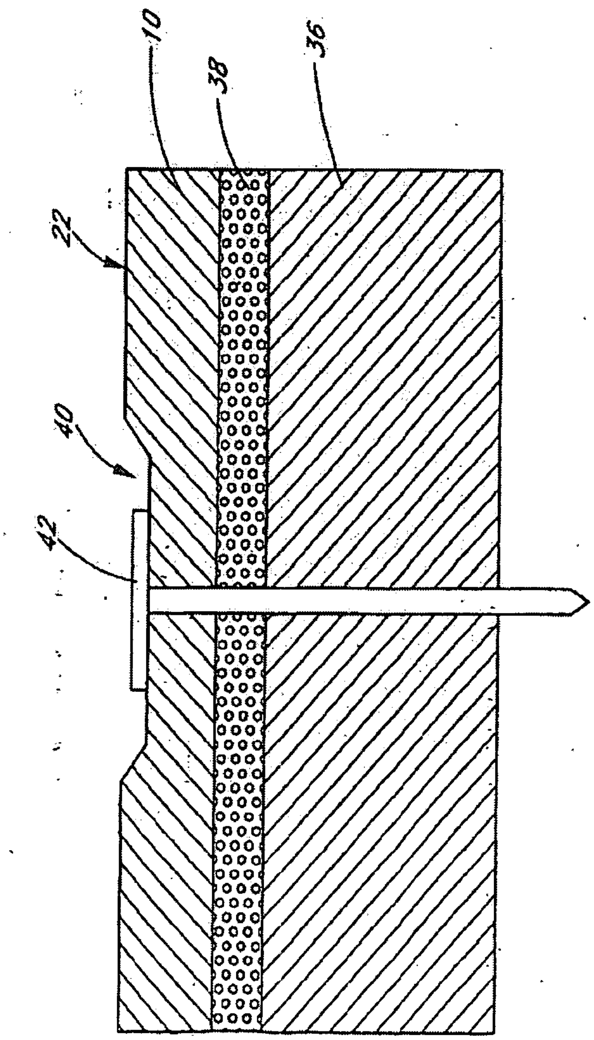

FIG. 13B

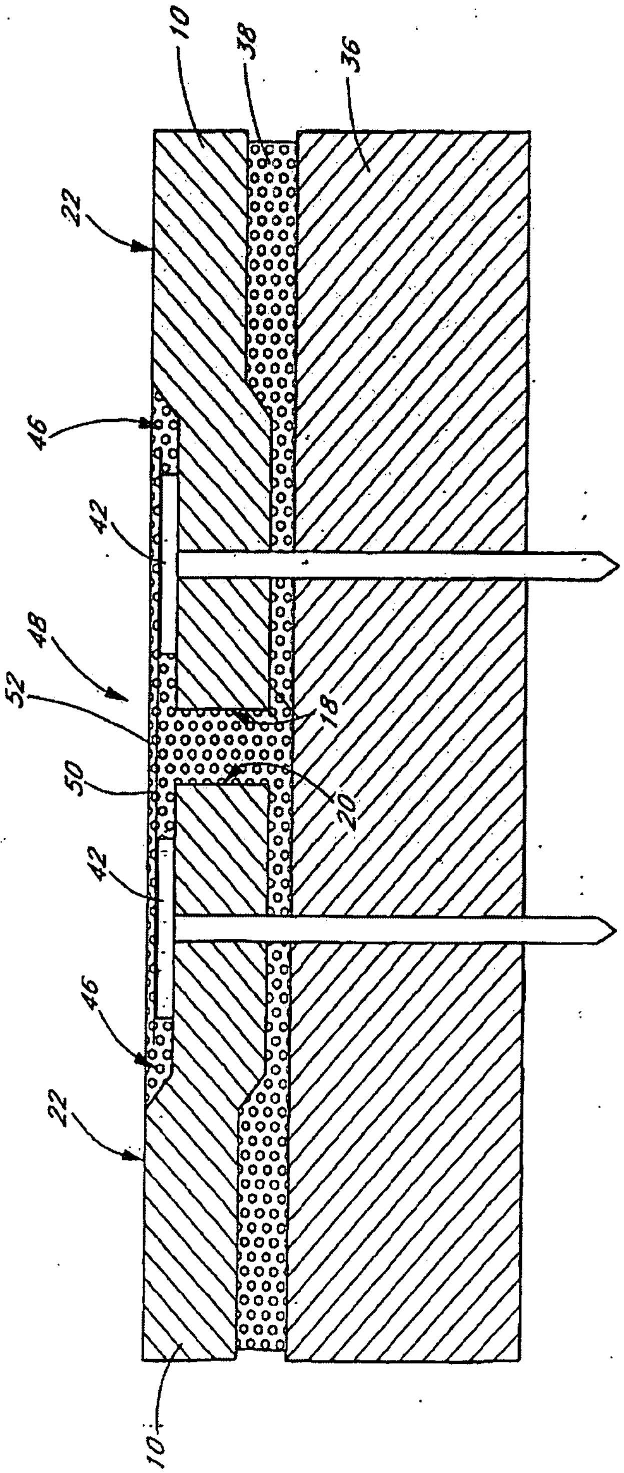

FIG. 14

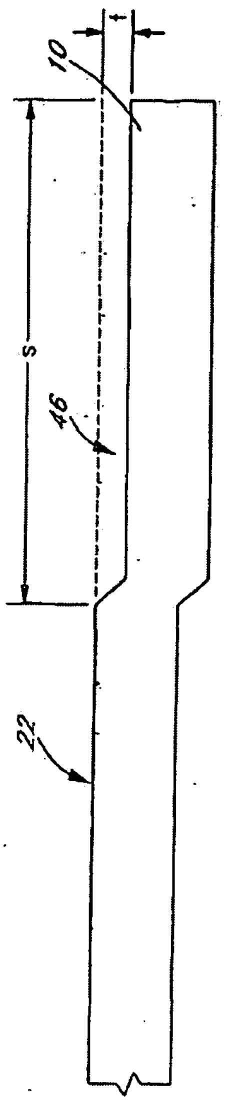

FIG. 15A

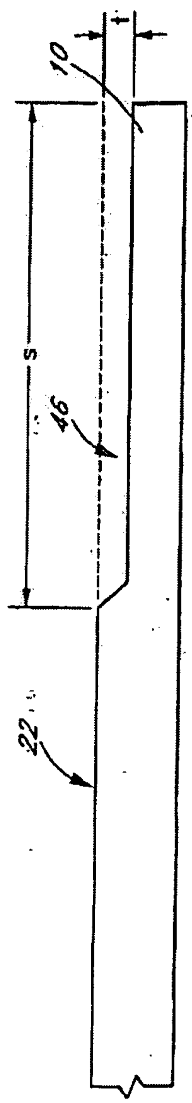

FIG. 15B

INTERNATIONAL SEARCH REPORT

International Application No
PCT/US 01/01908

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 E04C2/04

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 E04C

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 00 08271 A (BACCHIELLI) 17 February 2000 (2000-02-17)	1,4-15, 24-26, 33,69-73
Y	page 3, line 21 -page 5, line 12; figures 1,12,13	2,3, 10-12, 27,28, 41,42
A		48,55, 61-63,65
Y	US 5 924 213 A (LEE) 20 July 1999 (1999-07-20) column 3, line 37 -column 4, line 61; figures 1,2	2,3, 10-12, 27,28, 41,42

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
19 March 2001	26/03/2001

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Mysliwetz, W

INTERNATIONAL SEARCH REPORT

International Application No
PCT/US 01/01908

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y A	EP 0 482 810 A (DOMTAR INC.) 29 April 1992 (1992-04-29) column 11, line 40 -column 12, line 56; figure 10C	48-53 58
Y A	US 1 995 393 A (MANSKE) 26 March 1935 (1935-03-26) page 2, line 34 - line 48; figures 7,8,10	48-53 55,60
A	US 1 634 809 A (WEISS) 5 July 1927 (1927-07-05) figures 6,7,9	54

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/US 01/01908

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US 1634809 A	05-07-1927	NONE	